Conservation in Canada

Natural Resources and Historic Sites

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CONSERVATION IN CANADA

Ottawa 1971

FOREWORD

The following report dealing with conservation in Canada has two parts; the first part is a synopsis of all the reports and their recommendations for action, and the second part gives the reports in full with their own individual synopses. Three appendices deal with site reservation proposals by the Canadian Committee of the International Biological Program, the areas of National and Provincial Parks classified according to objectives and land use, and a list of international, federal, provincial and private organizations concerned with conservation in Canada.

The emphasis throughout the report is to provide a description of the resources, their value to man, the effects of man upon them and the steps taken to preserve the resources and the adequacy of these measures. Finally proposals are made for action.

The reports deal with the atmosphere, individual biomes, non-renewable resources, special problems and conservation legislation.

The report was prepared by a Task Force on Conservation of Natural Resources and Historic Sites, and individual reports in Part II have been contributed by members of the following organizations:

1. Canada Department of Agriculture

2. Canadian Committee of the International Biological Program

3. Department of Energy, Mines and Resources
    a. Geological Survey of Canada
    b. Mineral Resources Branch

4. Department of the Environment

    a. Canadian Forestry Service
    b. Fisheries Research Board
    c. Canadian Wildlife Service
    d. Meteorological Branch
    e. Water Planning and Operations Branch

5. Department of Indian Affairs and Northern Development
    a. National and Historic Parks Branch
    b. Northern Economic Development Branch

6. National Museum of Man, Ottawa

7. National Research Council of Canada

8. University of British Columbia, Faculty of Law

9. University of Saskatchewan, Department of Plant Ecology

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Chairman, Task Force

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PART I

SYNOPSIS OF REPORTS ON CONSERVATION IN CANADA

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SYNOPSIS OF REPORTS ON CONSERVATION IN CANADA

1. INTRODUCTION

The following report is a general statement on the present state of conservation in Canada based on the reports on individual resources given in full in Part II of the Basic Paper. The report briefly describes the resouces, the effects of man upon them, present action being taken to conserve resources and suggests conservation actions needed in the future at both national and international levels. The report covers both renewable and non-renewable resources, but does not deal in detail with topics discussed in other Basic Papers (monitoring of the environment, soil, gene pools).

Throughout the report conservation is considered in its broadest sense and includes resource conservation by wise management as well as site preservation for particular purposes such as scenic beauty, recreation, education and science.

2. DESCRIPTION OF THE RESOURCES

Canada is one of the largest countries in the world, and contains 9.2 million sq. kilometers (3.56 million miles) of land surface. Almost half (48%) of this land is covered in forest, about 8% by farm land, and the remaining 44% by muskeg, tundra, swamp, grass, brushland, and urban areas. Muskeg alone occupies about 1.29 million sq. kilometers (500,000 sq. miles), and most of the remaining land not covered in forest or farms consists of tundra.

The country borders on three world oceans (Atlantic, Arctic, Pacific), with a narrow continental shelf in the west, and a wide one in the east. It also contains the major inland sea of Hudson's Bay, has the longest national coast line in the world, and contains or shares 15% of the world's surface fresh water. Major physiographic features include the 1,813,000 sq. kilometers (700,000 sq. miles) of Precambrian Shield which dominates a large part of central Canada, mountains as high as 6,054 meters (19,850 feet) in the western Cordilleran Region, the extensive plains of the prairies, many large islands (e.g. Newfoundland, the Arctic Archipeligo, Vancouver Island) including the largest island in the world on a body of fresh water (Manitoulin Island, Ont.). The landscape has been greatly influenced by the ice sheet of the last glacial period.

There is a great variety of climates, and it is no exaggeration to say that both peaches and polar bears occur within a single province (Ontario). In the Maritime provinces and on the west coast the climate is oceanic, in central Canada it is continental, and to the north and on high mountains there are severe alpine, subarctic or arctic conditions.

Canada is still immensely rich in both renewable and non-renewable resources, particularly as regards water, forests, fisheries, and deposits

of oil, gas and minerals. Much of the nation's wealth is based on these resources, a wealth that has largely developed in less than a century. The population is still relatively small (about 20 million) for so large a country, i.e. about one tenth the population of the United States. Canada is essentially a wealthy nordic nation of relatively few people on a large land mass with natural resources of great potential that are still largely unexploited and to a certain extent still unexplored. The severity of the climate in the northern areas has resulted in relatively slow exploitation and development compared with the United States, and in many ways a parallel can be drawn with Russia. In the more densely populated and developed countries high quality natural resources are rapidly dwindling. Already other nations are looking towards Canada to supply their industrial needs. Demands on these resources are bound to increase, and pressures on previously uneffected northern areas are already apparent. There are many examples in other countries of the dangers of resource exploitation without thought for the future or consideration of values other than private gain. Canada is still in a position of being able to conserve her still largely undisturbed and unexploited resources for the maximum long term benefit of both the nation and mankind in general.

3. THE VALUE OF THE NATURAL RESOURCES

3.1 THE ATMOSPHERE

The basis of life on earth is the energy income from the sun, the mineral components of the earth's mantle, water and atmospheric gases. The interaction of these factors affect the climate which is the dynamic force influencing every process on the earth's surface. Even a small change in any of the factors affecting climate has a profound effect upon life. Climatic forces are continually changing and may fluctuate or cascade in one direction as in the case of the major glaciations of the past. Changes in the gaseous composition of the atmosphere, as well as changes in air turbidity and reflectivity of the earth's surface, all influence climate. These changes can be and have been caused by natural phenomena such as fires and volcanic activity, but today man's activities are on such a scale that he too can effect these factors and thereby change the climate, often inadvertantly and unknowingly.

Climate is not just a national commodity; it is a resourse shared by all people's of the world. A change in climate in Canada could have reverberating effects throughout the whole biosphere.

As well as being the controller of life, climate has determined the extent and location of man's activities in Canada. Most of the major, undisturbed natural resources of the world are in areas of severe cold which man finds hard to endure. These severe climates have tended to protect resources from early intensive exploitation, particularly in the case of Canada and Russia.

3.2 TERRESTRIAL RESOURCES

The indigenous terrestrial ecosystems of Canada reflect the varied edaphic and climatic factors, as well as a history of periodic inundation by the ice sheets of the glaciation. The tundra, muskeg, forests and

grasslands and their associated soils, constitute a massive sink of carbon, the importance of which in the atmosphere's carbon cycle is still not fully understood.

The huge area of forest (4.43 sq. kilometers, 1.71 million sq. miles) is one of the world's major land resources, and is vital to Canada's economy; it accounts for 22% of Canada's foreign currency and employs directly 4.5% of the country's labour force. In addition the forest and the associated water courses and wildlife provide a large and varied recreation facility not only for Canadians, but also for 35 to 40 million visitors per year from the U.S.A. who spend annually $0.7 to $1.2 billion. Many major drainage basins are often located on forest land.

The grasslands are also a major resource, and man has tilled these areas to grow agricultural crops and has grazed domestic animals. About 70% of the grazing capacity of these areas is provided by natural vegetation, but examples of natural ecosystems of this resource have nearly disappeared.

It is only recently that the tundra and muskeg have been regarded as resources of value to man, although they have supported wildlife necessary to the survival of the indigenous peoples of the north, of value for recreational hunting and with considerable aesthetic appeal to man. It is now realized however, that many muskeg areas have potential as organic soils for agriculture and forestry, and these soils are now the basis of a multi-million dollar horticultural peat industry. The muskeg peat also has promise as a medium for cleaning-up oil spills and water polluted with elements such as mercury.

All these terrestrial ecosystems are of considerable scientific interest. Except for grasslands, they are all still relatively undisturbed by man and afford considerable opportunities for studies of processes of natural ecosystems and population dynamics. Some tree populations for example are still in a state of migration and evolution, and these natural phenomena can still be studied. We also know very little about the processes of northern ecosystems other than forest, and there is an opportunity to study the fragile equilibrium of these systems and the performance of biota under stress.

3.3 AQUATIC RESOURCES

The aquatic resources of Canada provide electrical power for industry, water for industrial processes and agricultural irrigation, water for the population to drink, a medium for recreation, and valuable salt and fresh water fisheries. Water, in common with the atmosphere also provides a medium for carrying away industrial and human wastes from the source of their production, but this use is responsible for the country's pollution problems. The commercial fisheries are presently valued at $400 million annually, and recreational fishing attracts three million people who spend $500 annually on ancillary goods and services. Marine mammals are important as a source of diet in the Arctic.

3.4 NON-RENEWABLE RESOURCES

It is almost superfluous to describe the value of non-renewable minerals to man, as every developed nation has been built upon minerals and

every developing nation foresees its growth through minerals. For Canada, which has characteristics of both developed and developing nations, minerals are doubly important. Canada's consumption of energy per capita is one of the highest in the world and this energy is based on mineral fuels. Canada also relies to a great extent on mineral exports for jobs, public revenue and foreign exchange.

Historic and geological sites are also non-renewable resources. Examples of man's historical heritage in Canada and the associated historical discoveries constitute an avenue whereby man can learn from his past how to understand himself better, profit from experience to avoid past mistakes, and cope better with problems of the future. The sense of history offers a continuity of identity in a changing world. Man has a great curiosity about his historical heritage, as illustrated by rapidly increasing attendances at museums and historic sites. Although a dollar value cannot be placed on the intellectual, emotional and aesthetic values of historical resources, wise exploitation of such resources generates considerable revenue from visitors. Geological sites, such as examples of rock formations and rich fossil beds, also generate a revenue from visitors quite apart from their educational and recreational values.

3.5 URBAN CENTRES

The problem of rapidly increasing urban populations is raising problems of urban land use which urgently need solution. Urban greenbelts are being developed in at least two locations in Canada to control ribbon development and urban sprawl, a problem common to most urban areas. Greenbelts also protect agricultural activities on sites best suited to them, and provides space for parks and outdoor recreational activities. The conservation of these greenbelts is essential to the controlled growth of urban areas and the well being of urban populations.

While conservation in the broad sense can be justified on a basis of economic necessity and the current well-being of man, the fact cannot be ignored that man today has a moral obligation to leave to future generations a world of abundant and diverse resources. This moral obligation alone warrants the active conservation of man's heritage.

4. THE EFFECTS OF MAN ON THE RESOURCES

4.1 GENERAL STATEMENT

The effect of Canada's indigenous peoples upon the biosphere has in general been very limited. It is true that they burned forests but nature also did this on a grand scale. The early European settlers were mainly concerned with clearing forests for agriculture, felling high grade trees for timber, trapping fur bearing animals and fishing on the continental shelf. To begin with these activities were concentrated on the east coast but gradually man penetrated westwards along the main rivers and lakes. It is only in the last 50 to 100 years that Canada has begun to utilize her mineral resources on a large scale and this has led to a marked increase in natural wealth. The development of the mineral based industries, as well as other industries, has been accompanied by adverse effects upon the renewable natural resources of tundra, muskeg, forests, grasslands and fisheries. Industries have also been responsible for destruction of non-renewable geologic and historic sites.

It is not possible to consider the conservation of renewable and non-renewable resources separately in Canada; the two resources interact at both ecological and economic levels. The country's minerals need to be mined, processed and used if national prosperity is to be maintained. Whatever the scale or precautions taken the mining and processing are bound to affect natural ecosystems to some degree. It is a question of how much man is prepared to lose in order to obtain the benefits of power and wealth that accrue from mineral production and utilization.

The inroads that man has made into Canada's resources, however, are still relatively small compared with what is available. A great deal of the potential ill effects of resource utilization have been prevented by the development of resource use practices aimed at maintaining the resource for long term use by man. This particularly applies to resource practices such as forestry and fisheries where the goal is sustained yield by replacing what is taken out.

4.2 THE ATMOSPHERE

The increasing industrial development of Canada and other nations has affected the atmosphere by production of particulate and gaseous emissions which affect the physical and chemical properties of the atmosphere thereby affecting the transmission of sunlight. Land uses such as forestry and agriculture which involve changes in the vegetation affect the reflectivity of the earth's surface. All these effects ultimately influence climate which in turn controls all processes of the biosphere. The effect of man upon the climate is potentially more hazardous on a global scale than his adverse effect on individual biomes. Since 1940 there has been a cooling trend in the northern hemisphere and a corresponding 4% reduction in solar radiation from 1940 to 1960 which may be due to increased atmospheric turbidity. Consequently there has been a marked increase in the arctic pack ice. Even slight changes in the energy balance due to man's activities can cause major climatic changes.

Compared with other industrial countries, Canada still has relatively clean air except in industrial areas and areas affected by drift of pollutants from the industrial complex of the United States. Certain areas such as valleys and coastal areas are more affected by pollution than others due to the topography and climate impeding pollutant dispersal. Canada's arctic areas are particularly prone to damage by pollution due to inversions restricting dispersal, the inability of ecosystems to recover rapidly from damage, the slow decomposition of materials by nature, and the critical equilibrium of land and life forms. With the increasing development of the north, this sensitivity of the northern biomes to damage needs to be constantly borne in mind.

4.3 TERRESTRIAL RESOURCES

The effects of man upon the terrestrial biomes in Canada increases in severity from north to south, following the national pattern of settlement and development. Large tracts still remain relatively undisturbed, but with improving access and increasing pressures on the north this situation may not remain for long.

Man has affected terrestrial ecosystems by either changing the land use or exploiting the resource and maintaining it in a modified form. The grasslands of western Canada have been modified by increasing grazing intensity and

by tillage to grow wheat and other crops. The increased grazing has increased the proportion of short growing and unpalatable plant species, and modified the soil surface by trampling. The tillage has reduced the organic matter built up over many centuries in the grassland soils; for example 25 years tillage has in one case reduced this organic matter by 25%. There is still risk of soil erosion associated with cultivation. Very few of the truly indigenous grassland ecosystems survive today.

The enormous forest resource of Canada still remains relatively undisturbed by man compared with the forests of densely populated countries such as those in western Europe. This is largely due to the size and inaccessibility of most of the forest resource rather than early settlers' concern for its maintenance. This concern has only developed recently. The forest was regarded as an obstacle to be overcome by the early settlers intent on establishing farms. There seemed to be a surfeit of trees and little was done to replace what was taken out.

The clearance of forests for farming took place along the river valleys and on other accessible sites. Only the farms on the more fertile soils succeeded and persisted, and the unsuccessful abandoned farms are still being recolonized by trees. High grade timber has been extracted from Canada's forest since the eighteenth century, and locally (for example in the eastern Maritime provinces) the timber removed has exceeded replacement by tree growth. On a national scale, however, the annual harvest is at present below the allowable cut. By the year 2000, however, harvest will approach this allowable cut. At present about 800,000 hectares (2 million acres) of forest are harvested annually and about 680,000 hectares (1.7 million acres) are successfully restocked annually i.e. about 17% of the harvested areas remain inadequately stocked from a commercial forestry point of view. In addition there is a large backlog of 16.8 million hectares (42 million acres) of forestry land previously burned or felled which still remain inadequately stocked. The current forest policy is one of sustained yield reflecting the concern for the resource.

When forests are felled and managed this inevitably changes the forest from its original, natural state. This may be acceptable or even desirable from a commercial point of view as nature is more concerned with survival than producing an ideal commercial product. The effects of management practices on tree growth and succession have been intensively studied, but there are other effects about which we know very little. Forest management involves felling, skidding out logs, removal of timber from the site, burning and scarification for site preparation, fertilization, use of herbicides, insecticides and fire retardants, introduction of new genetic material, use of heavy machinery and road building. All these doubtless have profound effects on the microclimate, soil, vegetation and wildlife, but very little is known about the scale, duration or ecological significance of these activities.

The effect of forest industries, mining and other heavy industry on the forests is generally local. Instances are known of almost total destruction of vegetation near smelters (e.g. Sudbury) and vegetation may be damaged to a certain extent 40 to 50 miles away. On a national scale the affected area is still very small.

The Canadian forests and their associated lakes and rivers attract a great many tourists. The forest resource is, however, large; taking the country as a whole there are about 52 hectares (130 acres) per capita. On the basis of moderately accessible land of good recreation potential there are about 12 hectares (30 acres) per capita. Although demands for recreation are increasing site degradation due to trampling, littering, vandalism and other human activities is mainly localized at recreation centres. Fires caused by recreation are, however, of some significance, even though individual fires caused by recreation tend to burn smaller areas than fires due to other causes. Recreation is responsible for about 9% of the 1 million hectares (2.5 million acres) of forest burned annually in Canada costing the country at least $4.6 million annually quite apart from temporary effects on wildlife, scenic and recreation values.

The import of trees and forest products into Canada has led to the accidental introduction of serious forest insects and diseases, causing widespread destruction of spruces, white pine, true firs, beech and elm. From the late 1930's to the early 1940's about 19.6 million cubic meters (700 million cubic feet) of merchantable spruce were killed by introduced pathogens, and the valuable white pine has been virtually eliminated as a commercial species from some areas.

The northern biomes of muskeg and tundra have only recently been subjected to appreciable pressure by man. They have been locally affected by development of roads, hydro lines, seismic lines, flooding for power, mining, and (on the muskeg) utilization and export of organic soil. These northern ecosystems are sensitive to change and lack the ability to recover rapidly from disturbance and damage. The destruction of the permafrost could have disastrous and far reaching consequences, and its continuity is determined by the thermal balance of the soil. This balance can easily be upset by destruction of vegetation or small changes in climate. Although widespread serious damage to these northern ecosystems is not yet apparent, it could easily occur unless the processes are understood and the land is used from a position of knowledge.

In spite of the fact that centres of evolution of plants and animals and migratory pathways are potentially highly susceptible to destruction by man, in general these centres do not seem to be greatly threatened by man's activities in Canada at present. There are of course exceptions; the northern edges of some trees' distributions are under threat in the densely populated areas of Southern Ontario. Some evolutionary centres have been preserved in National or Provincial Parks, or are remote from man's incursions. Major migration pathways such as the Mackenzie Valley and the southern Yukon are so extensive that man is no immediate threat. This situation can, however, change rapidly and the increasing exploitation of northern resources means that even these remote areas may some day come under excessive human pressure.

4.4 AQUATIC RESOURCES

Man has had beneficial effects upon aquatic organisms by overcoming barriers to fish movement, introducing species, selective fishing to change genetic composition, selective breeding and suppression of predators. Aquaculture is also being encouraged in Canada, and major developments have been made in rainbow trout and oyster culture. Many provincial governments also have fish stocking programs for lakes subjected to intense recreational fishing.

Man has, however, affected tha nation's water resources and organisms of the aquatic environment by both industrial and domestic activity. Water used in industrial processes or used to carry away industrial and domestic effluents has polluted both fresh water and marine environments. The deterioration of the Great Lakes is undoubtedly due to industrial and domestic effluents, although it is still far from clear what factors are most to blame. As in the case of air pollution, contamination of water affects organisms at considerable distances from the pollution source and where the pollution includes insecticides it can affect many organisms in the food chain, including man. Trout and salmon populations in rivers have suffered from effects of pollution, and recently herring and other marine fish were killed by toxic effluent in the Atlantic off Newfoundland. The effects of mercury and DDT contamination of water and damage to littoral ecosystems and sea birds by oil spills have caused much public concern. Animal wastes in runoff waters may cause high coliform counts in shellfish. Commercial over-utilization of some fish species and under-utilization of others has greatly affected the marine fisheries.

Man has also diverted and controlled water movement to provide electric power and water for domestic and industrial uses in Canada. The creation of dams and the consequent inundation of valley land and reduction in river flow have been the cause of much controversy. Canada has a great deal of water, more than it can presently use, but demands upon it are increasing and there has been much public discussion of the desirability of entering into long term water export commitments with the United States.

By his disposal of toxins in the world's oceans man is capable of profoundly affecting marine organisms. These organisms are in a delicate state of equilibrium with one another and their environment and any major change could have far reaching effects. The oceans profoundly affect the global oxygen and carbon dioxide balance, and are in fact an immense sink for these gases. We do not yet know the extent or degree of man's influence on these oceans, but any upset of the balance could affect world climate.

4.5 NON-RENEWABLE RESOURCES

Most of the public concern about the environment has been directed at conservation of the renewable resources of the country. Non-renewable mineral resources are more often than not of concern to Canadian conservationists mainly for the adverse effects of mining and processing on the biosphere. Conservation of these mineral resources is seldom equated with conservation of the climate or terrestrial and aquatic ecosystems, yet they are all parts of the same national and global conservation picture. The drive to conserve minerals stems directly from the fact that they can be exhausted and cannot be replaced in situ. With better conservation, including increased recycling, exhaustion of minerals will be delayed. Canada still has vast untapped mineral resources, many of them of high grade. With developing technology minerals can be recycled, so that the mineral supply may be nearly limitless. This does not, of course, apply to fossil fuels such as oil, gas and coal. Once these have been burned they are lost forever.

The effect of man on Canada's geologic sites, such as examples of rock formations, glaciation and fossil beds, has been limited. The main damage has been to some accessible fossil beds by collectors.

Canada's historic resources are vulnerable to damage but not as amenable to authentic re-creation. Historic sites are destroyed by natural causes, but the main agent of destruction is man himself. The construction of dams, reservoirs, highways and pipelines obliterates many archaeological sites, and urban renewal and sprawl take an annual toll of Canada's surviving old buildings. These losses are all the more serious because their extent is often unknown.

In Canada, therefore, the effect of man on the natural resources is not as great as in more densely populated countries with milder climates. The size of Canada, the ruggedness of the terrain and the severity of the climate have all tended to impede widespread intensive development and exploitation of resources. Nevertheless the influences of man are appreciable and have had far reaching effects.

The nation is at the beginning of a new phase of development in the north. It is therefore timely to consider ways of overcoming man's adverse effect on his environment, reach a deeper understanding of the natural processes involved, and thereby formulate land use policies based on sound ecological and economic principles.

5. ACTIONS TAKEN TO PRESERVE THE RESOURCES

5.1 GENERAL STATEMENT

The conservation of Canada's natural resources, which are the nation's main source of wealth, is vital to the well being and prosperity of the nation. Until the present century the nation was mainly concerned with resource exploitation as the resources seemed inexhaustable. Apart from local reservation of land for scenic values, legislation relating to a few local resources in danger of depletion, and active protection from disasters such as fire, few measures were taken to preserve these resources prior to 1900.

During the present century there has been increasing concern for resource conservation. Conservation measures have steadily increased, and have gained considerable momentum in the last ten years from the increasing public concern for the human environment and demands for action. These conservation measures include land use inventories, the development of better land use criteria and methods, reservation of sites or resources for special purposes, protection of resources from natural disasters such as fire, legislation to limit resource use and regulate disposal of industrial and domestic wastes, research on natural populations and processes to provide a sound base for management prescriptions, and education at both university and public levels. The increasing public concern is reflected by the fact that there are more than one hundred organizations concerned with natural resource conservation in Canada. The conservation issues are being affected by a growing demand for outdoor recreation facilities by an increasingly affluent and mobile population. There is also an increasing realization that man's influence on Canada's resources is of international as well as national concern, as movements of air and water and the associated biota are not confined by national boundaries.

The Canadian approach to conservation has been and still is mainly pragmatic; recently, emotion has sometimes tended to distort the facts and

confuse the priorities. Canadian conservation has been largely concerned with maintaining and preserving things that people can use and which have a tangible economic value. In the case of forests, for example, conservation has been and still is mainly concerned with trees of economic importance. Similarly considerable efforts have been made to preserve game bird populations but little has been done to preserve non-game passerine birds. Site preservations have been mainly for recreational purposes. Recently, however, conservation of resources for scientific, educational and moral reasons has increased in intensity, sometimes in cooperation with international organizations such as the International Biological Program.

Canada has a well developed parks system which covers many terrestrial and aquatic ecosystems as well as geologic and historic sites. There are 24 federal National Parks covering 76,211 sq. kilometers (29,425 sq. miles) and more are being established. National Parks tend to be concentrated in the north and west of Canada. In addition there are 1,814 Provincial Parks covering 249,000 sq. kilometers (96,000 sq. miles). The National Parks have a uniform policy of preservation of sites for recreation with minimum disturbance, but Provincial Parks vary in their policy and use. Most provinces have different classes of park based on objective and/or land use, and commercial logging is permitted in some areas. In these parks also the emphasis is upon reservation for recreation.

The national concern for conservation of man's environment is reflected in a recent spate of proposed legislation at both federal and provincial levels concerned with pollution abatement, land use regulation, and site reservation for scientific purposes. The federal government is also in the process of reorganizing those federal departments concerned with inventory, research, regulation of the nations natural resources and associated research. A proposal has been made to form a new Department of Environment which will include such diverse interests as land inventory, pollution control, forestry, wildlife, fisheries, water, meteorology, and pollution control. Canadians are aware of the urgency of dealing with urgent conservation problems of both national and international consequence.

5.2 THE ATMOSPHERE

Efforts made to prevent man's changing the climate in Canada are mainly concerned with legislation and research aimed at controlling industrial and domestic pollution of the atmosphere, as these factors affect those physical and chemical properties of the air which control the energy balance and climate. These conservation measures may be locally effective in heavily polluted industrial areas, but they can only be effective on a national scale if other nations take simular measures. The difficulty at present is that although we know that pollution will affect the atmosphere in a certain way and thereby affect the climate, the interaction of the factors determining global climate is so complex that, although informed guesses can be made, we do not really know what these climatic changes will be. It is clear, however, that these changes could have disastrous consequences for man and other life forms.

5.3 TERRESTRIAL RESOURCES

The present intensity of conservation of terrestrial ecosystems reflects the extent to which they have been vital to man's settlement of Canada, the extent to which the sites can be used for other purposes and their size and accessibility.

Forests have been protected from fire and insects for many years, efforts made to achieve sustained yield by cut regulation, attempts made to restock felled areas, research carried out to support these activities, and legislation enacted to prevent importation of serious pests and diseases. The policy is one of conservation by good management as well as by site reservation. About 68,900 sq. kilometers (26,500 sq. miles) of forest have been set aside for national and provincial parks, game reserves and watershed preservation. Most of this reserved forest is used for recreation.

In spite of the huge backlog of 16.8 million hectares (42 million acres) of burned or felled forest land that has not been successfully regenerated to commercially valuable species and the 17% differential between area harvested and area restocked per annum, a great deal of Canada's forests still remain relatively undisturbed, and on a national scale, the annual harvest is still well below the allowable cut. Every effort should, however, be made to increase yield per acre and bring those unstocked sites with the necessary potential back into production.

Many forest types have been included in site reservations for parks; a great many of these forests have been preserved as part of the general scenery. Recently there has been an increase in sites reserved for specific scientific purposes. There is, however, little evidence of a systematic policy to retain examples of all the major forest types or forest areas of particular scientific interest such as those in a state of evolution and stress and sites in glacial refugia. In the parks system many forests have been included in wilderness or natural areas. In the National Parks the emphasis is on recreation and no commercial logging is permitted. In Provincial Parks logging policy varies, but the current trend is to restrict commercial felling. This raises the difficult question of how to manage forested wilderness and natural areas. If fire and insect attack (which affect natural tree succession) are controlled, it is doubtful if in the long term natural forest ecosystems will retain their primeval character. A great deal more needs to be known before such questions as these can be answered. The preservation of ecosystems is not just a question of legislation; the sites need to be managed and this needs both money and a sound management policy.

Grasslands have also been important to man in his settlement of Canada, but their soils can be used for growing agricultural crops which may be more profitable, at least in the short term. Consequently little has been done to preserve areas of natural grasslands, apart from their incidental inclusion in National and Provincial Parks. Even in the latter case they have not been managed to preserve their natural state. Attempts have been made to set aside small areas of grassland for research, and one such area is on a 21 year lease (Matador, Sask.), but no legislation exists to protect these areas from ultimate destruction. As in the case of the forests, even if examples of natural grasslands are preserved, a major problem exists as to how these areas should be managed to preserve the natural state, and how the costs of such management can be met.

Until recently the large areas of muskeg and tundra in Canada's subarctic and arctic regions were inaccessible to most people. The severe climate and the relatively low soil fertility discouraged most settlers apart from those concerned with the fur trade. For most of the summer much of the tundra is an almost impassable morass. Until recently

the principal users of these biomes were the indigenous peoples who depended largely on the wildlife for their sustenance, and few Europeans regarded these areas as a resource. Today, however, Canadians are looking northward to an increasing extent. The discovery of mineral and oil deposits in the north has increased the tempo of development and areas which were seldom visited by Europeans are now in danger of degradation by man. New federal legislation is being enacted to ensure managed and orderly utilization of water and land resources and prevention of needless damage to the northern environment. This legislation provides for restoration of damaged lands and the maintenance of acceptable environmental quality standards. Programs are being developed to detect and define environmental problems arising from northern resource development and to devise alternative operational procedures to minimize the risk of environmental damage. Projects in these programs include studies of effects of oil spills on tundra vegetation, influence of seismic lines on plants and soils, effects of heavy equipment on the tundra surface, and environmental surveys and inventories to provide support for environmental legislation. All these activities, however, are in their early stages. Basic research is in progress dealing with permafrost, distribution and density of terrestrial wildlife and the development of a bio-physical classification for the tundra.

The setting aside of wilderness areas such as Ontario's Polar Bear Provincial Park, will help to preserve some northern biomes and their animal populations. Many northern animals, such as the muskox, are in fine balance with their environment, a balance which could all too easily be upset by man's activities.

Efforts are being made to preserve muskeg areas both in the north and south of Canada to serve as reference points against which changes in muskeg due to man's activities can be measured. A preliminary selection of about 20 sites has been made, but these do not yet have any official status. Some muskeg areas are contained within the parks system.

So far there has not been a sense of urgency to preserve evolutionary centres of plants and animals in Canada, and little has been done to ensure their survival. Exceptions are the efforts of the federal government to save the Lake Athabasca sand dunes in the north, and restrictions on collecting rare or localized plant species in the country's parks.

The overall picture, therefore, is of disappearing natural grasslands with inadequate legislation to prevent their destruction; a vast and still largely undisturbed forest resource being maintained by protection; management for sustained yield and site reservation mainly for recreation; and a recent increase in man's activity in the northern muskeg and tundra necessitating legislation and research to find ways of protecting the sensitive biomes, these northern conservation measures still being in the early stages. There is a scarcity of information on the effects of man's activities on all these biomes, a lack of a systematic system of preservation of sites representing main types of the biomes, and a problem of how to manage natural or wilderness areas in which it is necessary to control natural catastrophies which determine natural succession.

5.4 AQUATIC RESOURCES

Many of the deleterious effects of man on his aquatic resources are outgrowths of historical practice, insufficient knowledge, ad hoc policies, social and economic conditions, and national and international competition. Some of Canada's aquatic resources are shared with other nations and must be managed jointly. The national development and conservation of fisheries and marine mammal resources (seals and whales) of such common concern is ensured through membership in nine international fisheries commissions and one international council. Canada cooperates with many nations in obtaining scientific data and formulating management proposals. All nations follow the conservation principle of maintenance of continued high yield, but individual goals differ within and between nations, depending upon species, locality, socio-economic factors, production costs, market demand and competing water uses. By amendments to the Territorial Sea and Fishing Zones Act of 1970 Canada's territorial sea was extended from three to twelve miles. This extends to these additional waters the protection of Canada's anti-pollution programs. Canada has embarked on a policy to reduce pollution and improve the aquatic resource in all national and shared coastal and fresh waters.

The federal government has embarked on a program to create marine National Parks which will contain areas closed to commercial fishing providing for recreational use of the surface as well as the underwater environment.

5.5. NON-RENEWABLE RESOURCES

In the past almost all the conservation activities in Canada have been concerned with the environment and renewable resources rather than with mineral resources. The state of environmental protection during mineral production and consumption is still far from satisfactory, and much remains to be done. The proposed federal and provincial legislation will afford an increased degree of protection of natural ecosystems as well as man by control of industrial emissions. In Canada there is a great awareness of these problems and a drive to do something about them. The same cannot be said about mineral conservation, about which little has been done. The conservation of minerals might go further than many of the more direct approaches to protect renewable resources. High grade mineral resources are still plentiful in Canada; while there is easy access to these there will not be a strong stimulus to develop recycling methods in industry.

In Canada the responsibility for the protection of archaeological and historical sites of local significance rests with the provincial governments. A number of these have enacted protective legislation and others intend to do so. The chief problems appear to be lack of funds devoted to law enforcement, site protection and public education. Work is being concentrated on inventory of historic sites and provision of adequate protective legislation. The immediate aim is to define the problems and develop surviving resources. Early architecture, the most vulnerable of the country's historic assets, is being recorded in provincial and federal inventories; the federal program (Canadian Inventory of Historic Buildings) gives high priority to a detailed national survey of building styles and surviving examples. The computerized methods being used could be applied in any country.

Many examples of geologic sites such as rock formations, fossil beds and glaciers are preserved within the National and Provincial Parks. Some fossil beds have been specifically preserved by lease or purchase by provincial governments (e.g. Quebec, Ontario). A considerable effort is being made to make the public aware of their geological heritage by setting up descriptive signs and plaques, publication of literature describing geologic features, and the establishment of outdoor geology courts in cities to interest the public in rocks and minerals.

5.6 URBAN CENTRES

The establishment of greenbelts in expanding urban areas is receiving increasing attention in Canada. The principles of how these greenbelts should be managed so as to restrict urban sprawl and ribbon development without unduly inhibiting growth are still in a state of development.

6. CONSERVATION LEGISLATION

It is clear that the overall legal structure, and particularly the institutional and tenurial arrangements for holding and managing protected areas, whether public or private, are of considerable importance. Generally, the Canadian legal system has a development orientation and does not readily accommodate protected natural areas and unintensive use zones such as wilderness areas. As a result special legal and administrative protective measures may be necessary. In particular efforts must be made to ensure that procedural safeguards are established to prevent removal of protected status except for clearly established reasons of compelling public interest.

An important means of safeguarding protected areas involves the interest, concern and expertise of members of the public. It has been suggested that public hearing requirements on re-classification and abolition decisions can be used to bring pressure on administrators by demonstrating that a status change is not in fact in the public interest. It has also been suggested that expertise in designation and management of protected areas can be provided by advisory committees including scientifically and technically qualified persons from outside the administering public agency.

7. THE ADEQUACY OF ACTIONS BEING TAKEN

In view of Canada's history, the present extent of conservation achievement is surprising. The European settlers had to contend with considerable hardships imposed upon them by the Canadian environment; they regarded the climate, the rugged terrain and seemingly limitless forests as enemies to be overcome rather than resources to be preserved. This attitude is on the decline and Canadians feel increasingly responsible for maintaining their resources by good management and preserving examples of special aspects of these resources as part of Canada's heritage.

The main current threat of deterioration to man's environment both in Canada and elsewhere is uncontrolled disposal of industrial and domestic wastes, due to their potential influence on climate and the widespread distribution of toxins. The current proposed anti-pollution legislation and studies to find better ways of waste disposal in Canada will go a long way towards alleviating these problems, and the proposed regrouping of federal departments should stimulate a more coordinated approach. Measures taken to combat pollution, however, can only be realistic and fully effective

if the influence of pollutants on Canada's natural resources (including man himself) is understood and the consequences of pollution predicted in a quantitative manner. Resolution of this problem is dependent on research into the climatic and biological aspects of pollution, particularly on multidisciplinary studies of the interaction of the many components of industrial and natural systems. We know very little about the tolerance of biological systems to toxins or to climatic change. We do not understand the quantitative, long term effects of industrial wastes and different land uses on climate; nor do we understand many of the processes of circulation of toxins in biological systems and the powers of recovery of these systems from degradation. A great deal of this type of work can be done with mathematical models, but these models are only as good as the information upon which they are based and much of this information is sadly lacking. Research needs to be done at both the organism and systems levels.

Pollution is not the only threat to Canada's resources. Over use of resources, development of one resource at the expense of others, and land use practices carried out without understanding their long term consequences have all contributed to the at least local degradation of the human environment in Canada. As in the case of pollution this can be partly overcome by current and future legislation, but legislation and the development of wise land use practices can only be effective if they are based upon sound information. We know all too little about the effects of land use practices on the biological potential of the sites where they are carried out. Nor is there any common objective scientific procedure for assessing priorities of land use and conservation actions. This is partly due to the artificial hiatus that exists between renewable and non-renewable resources. There is a need for multidisciplinary studies of land use in Canada taking into account both renewable and non-renewable resources, and inclusion in these studies of social and economic aspects of resource utilization and conservation.

Conservation is all too often considered in isolation from economics. Effective conservation is, however, a matter of trade-offs i.e. consideration of what we are prepared to lose in order to achieve a particular gain, and what the long term consequences of these losses and gains will be.

Although Canadian university faculties include subjects relevant to conservation in their curricula, courses concerned with training for resource use (geology, mining, forestry, agriculture, fisheries, archaeology, etc.) tend to underemphasize the conservation aspect, particularly conservation in its broad sense. There is a need to increase the scope of education to include broad sense conservation not only within individual disciplines but between disciplines, and at public as well as university levels. It is only in this way that resource use in Canada can be developed in an integrated manner rather than as a series of conflicts. This particularly applies to countries such as Canada which are at the beginning of their resource development; they are in a position to benefit from man's past mistakes in the use of his environment.

Many surveys are going on in Canada at present on land use potential, forest sites, sites of scientific interest, mineral resources,

historic sites and many other topics. There is already a large bank of information on resources in various government departments. There are, however, gaps in our knowledge about particular resources. Some of these gaps can be filled by drawing on local unpublished knowledge of people with field experience, but limited surveys are still needed.

To a large extent there is the necessary legislation and organization to deal effectively with the aspect of conservation concerned with efficient resource management to produce consumable products such as minerals, wood, and fish. There is also the necessary legislation and organization to develop the recreational aspects of the resources. The weakest part of the system, at both legislative and organizational levels, is the aspect of conservation concerned with site preservation for scientific and educational purposes. A great deal of land has been reserved, but often there is no systematic coverage (except in the case of historic sites) of representative sites of scientific interest, nor is there a scientifically based philosophy for the management of such sites. The conceptual basis of management for such sites is often quite different than for sites yielding a tangible, consumable product. In addition existing legislation sometimes makes it difficult to preserve valuable sites and give them the necessary long term security.

In Canada, therefore, much has been done, but much remains to be done. The difficulties ahead are considerable, and many of them inherent in the federal system. To quote Prime Minister Trudeau in his recent reference to environmental problems in Canada: "There are no easy answers to these questions, for the problems they pose are often contradictory. But that does not mean there are no answers .."

8. ACTIONS NEEDED

8.1 COMMON ACTIONS NEEDED FOR RESOURCE CONSERVATION

Before summarizing the actions needed to promote conservation of Canada's individual natural resources (atmosphere, terrestrial and aquatic), there are certain common issues which apply to most resources. There is an overall need for:--

i The education of persons concerned with Canadian resource management in the complexity and sensitivity of the environment and the merits of taking a total systems approach to resolve conservation problems. Also to inform the public on the need for and aims of conservation in the broad sense.

ii Research to generate the necessary basic information to provide resource managers with the knowledge they need to formulate ecologically, economically and socially sound policies. This information is also needed to construct the models that are an essential part of the systems approach. It will also be necessary to review what information is available, so that research needs and priorities can be defined.

iii Research to discover the response of organisms and ecosystems to contamination by pollution in Canada, together with the resilience of these organisms and ecosystems following natural or man-made disturbances.

iv Research on ecosystems of scientific interest such as populations which are still evolving; the long term effects of management practices on the soil, vegetation, wildlife and microclimate; the dynamics and diversity of plant and animal populations; ways of managing resources so as not to conflict with aesthetic and recreational values in sensitive areas; the relationship between the public and the resources including the impact of increasing recreational pressures; quantification of the value of the resources in their roles as recreation facilities.

v To consider the national and international conservation picture as a whole, including both renewable and non-renewable resources, so that conservation priorities can be decided upon and resources in immediate danger of degradation designated. This priority assignation will need to take into account socioeconomic factors as well as scientific and moral issues.

vi Re-examination of current legislation governing land use to discover whether or not modifications are needed to facilitate implementation of necessary conservation measures.

vii Coordination of national and international organisations' research on common conservation problems. This particularly applies to research on plant and animal populations common to Canada and neighbouring countries.

The following sections deal with actions needed to maintain individual resources:

8.2 THE ATMOSPHERE

i Research on ways of predicting both the effects of man's activities on the atmospheric environment and the effect of changes in the atmosphere on the components of the biosphere in a quantitative manner. This particularly applies to arctic areas where there is a delicate equilibrium between climate, soil, permafrost, vegetation, wildlife and the snow and ice fields.

ii Studies of the association between topography and inversions and other weather patterns which may result in local pollution crises, in order to provide guidelines for planning of industrialization and emergency actions.

iii Acquisition of climatological information where needed to combat disasters such as oil spills and escape of hazardous gases.

iv Studies of the sensitivity of a wide range of species (bioindicators) to atmospheric contaminants to provide a basis for planning monitoring systems.

v Provision of climatic networks to measure spatial variation of those factors critical to the living systems, and record climatic conditions in conservation areas and areas now damaged by pollution to monitor possible dangers and record environmental change respectively.

8.3 TERRESTRIAL RESOURCES

i Development of a national forest conservation philosophy covering both resource maintenance by good management of productive forests as well as forest reservation for scientific, cultural and recreation purposes.

ii Designation of national priorities of forest site reservation taking into account their value to society and the immediacy of danger of their destruction.

iii Examination of the possibility of integrating the work of agencies concerned with different aspects of forest conservation so that a multidisciplinary approach can be taken to forest conservation problems.

iv Strengthening regulations restricting movement of trees and plants to reduce the risks of import and export of serious pathogens.

v Intensification of farmer's awareness of dangers of wind erosion on grassland sites and encouragement of use of preventative measures.

vi Legislation to enable representative examples of natural forest, grassland, muskeg and tundra ecosystems to be set aside and protected from degradation in perpetuity, and financial provision for their study and management.

8.4 NON-RENEWABLE RESOURCES

i The development of a more careful social accounting system reflecting the net social gain from additional consumption of mineral resources, taking into account the effects of mineral production and consumption on the atmospheric, aquatic and terrestrial resources.

ii The preservation of examples of mineral deposits at least for display for educational purposes, just as fossil sites have been preserved for posterity. Mineral deposits also, deserve protection to meet the country's long term requirements.

iii Consideration of the possibility of charging the cost of salvaging endangered historical resources to the project which occasions their loss.

iv Enacting legislation to restrict export of antiquities, and to protect archaeological sites on land and under water; and further stimulation in Canadians of an awareness and concern for their historical heritage.

9. URBAN AREAS

i Extending the greenbelt concept to other major urban areas in Canada to limit ribbon development and maintain land suitable for non-developmental use near cities.

PART II

CLIMATIC ASPECTS OF CONSERVATION

CONTENTS

CLIMATIC ASPECTS OF CONSERVATION

1. INTRODUCTION

Climate is a dynamic force which shapes the environment and influences almost every activity. The energy received via the atmosphere is the source of life, and with other climatic controls it governs biological productivity. A change in climate alters the balance of forces affecting nature, possibly with profound effects. In fact, climatic forces are continually changing, and changes of short duration, such as climatic interludes and extremes, act as severe controls on ecosystems and may threaten the survival of certain species. Major, longer duration climatic changes of the past have completely altered the ecology of vast areas.

The cause of climatic change has long been disputed, but it is clear that atmospheric contaminants in the form of gases or particulate matter can be significant factors. Another major factor is the alteration of the earth's reflectivity. Snow-covered areas are particularly prone to changes in their reflectivity, also they can have a major effect on the earth's heat budget through their expansion or contraction. Significant alterations in climate may occur through changes in land use such as by the practice of agriculture, removal of forests, the creation of cities, large-scale flooding and changing ocean currents. Replacement of a boreal forest by fields of snow may reduce the reflectivity of an area by a factor of seven.

Not only does the atmosphere respond to contaminants but it acts also as the vehicle by which contaminants are transported to sensitive ecosystems and species, and as a medium in which chemical changes occur.

The importance of understanding and coping with climate in conservation practices is therefore self-evident. Conservation means survival, and survival is dependent on a favourable climate. Modern technology can change both the atmosphere and the hydrosphere and therefore presents not just benefits, but grave risks. Throughout geological time the ecosphere has changed by evolution and extinction. Persistence of a species has demanded a dependable environment. Nature has aided in achieving climatic stability such as in storing surplus energy through photosynthesis. However at present the natural productivity of the earth is being affected and climatic stability threatened by man's activity. Energy consumption, and pollution are increasing at an exponential rate. They have an inescapable impact on the environment and thereby the ecosystems of our time. Furthermore the nature of the probable impact is poorly understood. It is of the greatest urgency that we determine as quickly as possible if the effects of man are reversible or permanent and also if there is a cascading effect which may be completely uncontrollable and therefore disastrous! Unfavourable conditions will occur naturally or as a result of the impact of modern technology. Knowledge of potential hazards, natural or induced, can aid in conservation through sound, preventive design, or quality control measures, i.e. through sound management practices.

Meteorological data acquisition and research in Canada is the responsibility of the Canadian Meteorological Service. Started in 1871, the national weather network was designed initially to meet the needs of the times. Economics and expediency shaped a network which provides very basic data mainly for areas of high population density. Records from more remote areas were collected originally to serve marine interests, and later to serve other specific users.

The need for good-quality, long-duration records led to an attempt to continue maintenance of some, and create other stations where secular change was minimal, either by contract or through agreements such as at Research Stations of the Department of Agriculture. These records may prove invaluable in establishing norms, and in predicting climatic change.

Modern conservation practices and environmental quality problems require a more rigorous measuring, monitoring and research program than has been possible previously. The Canadian Meteorological Service has attempted to develop systems to resolve local problems and as required for the International Biological Programme. Canada is also co-operating with the World Meteorological Organization and other organizations in the establishment of both global and national monitoring systems which will provide background information on quality. Urban and provincial monitoring systems are operated or being developed by other levels of government. The protection of many susceptible areas, however, requires even more intensive measurements than are presently taken, and technologies which are now only in the development stage.

2. SENSITIVITY TO CLIMATE

Climate involves the total atmospheric environment. Whereas temperature and precipitation are the most commonly known, the atmospheric environmental factors shown to be biologically effective are numerous. They include various forms of visible and invisible radiation, dust, smoke, smog, vapours, gases, organic particles, electricity and atmospheric pressure. The overall impact of many of these components is poorly understood and their measurement often infrequent. Furthermore these elements transported by the winds may be damaging to materials and life. The magnitude of the transport capability of the atmosphere is, at times, remarkable: for example, large volumes of dust, 2.5 $\mu gm\ m^{-3}$ are carried from Africa to Barbados by the trade winds (1).

Evidence of biological sensitivity to climate is common during periods of weather extremes. The Canadian Arctic provides some excellent examples of this sensitivity because of the delicate balance of factors which control survival in high latitudes; however the impact is often equally severe at lower latitudes.

The snow cover over Canada's northlands is a vital factor to winter survival of many northern plants and animals to whom its presence or absence is critical. Small mammals are extensively killed under conditions of

winter drought which deprives them of a habitat, water supply and access to food. Untimely spring melts may also kill rodents, and delayed melts deprive birds of nesting sites with the resultant loss of hatch. Spring blizzards are responsible for major losses of caribou calves, and deep, crusted snow denies forage to herbivores. A snow depth of less than 40 cms is essential for the maintenance of permafrost and for easy foraging. Fifty cms depth is generally needed to prevent winter-kill of vegetation. Interludes in climate which cause significant deviations from average conditions result in massive losses of plant and animals. Writing about Greenland, Vibe (2) noted "in warm-snow winters animals are exposed to lack of food and consequently starvation, and only a few survive".

Most plants and animals live precariously, taking refuge in a particular microclimate near the ground which favours their survival. The microclimates of habitats are easily altered, as, for example, by the removal of tall vegetation, by land manipulation, and possibly by physical changes occurring with the air that may alter the transmission of sunlight and energy. Modification of the energy flow affects fundamental biological controls such as permafrost, which occurs over most of the Canadian Arctic, and may cause thermal erosion and the conversion of permafrost areas into bogs or lakes.

The hazard of change to conservation and management is most apparent in zones of large climatic shear. Slight reductions in the mean annual temperature may have catastrophic effects on agricultural areas bordering Canada's boreal forest because of the shorter growing period and reduction in heat which is needed for crops to reach maturity. Kristjansson (3) has estimated that a one-degree drop in temperature in Iceland means a 15 percent reduction in crop yields, and possible migration of the herring fishery from Icelandic waters. Equally disastrous results can occur in Canada which exploits the northern limit for economic growth. Wet interludes may be equally damaging to agricultural operations, converting semi-arid areas to swamps, whereas extended drought can cause economic disaster in any agricultural area, and menace the survival of areas and species, directly or indirectly through fires, erosion and the loss of natural potable water supplies. The ecosystem present at any one time is the product of factors which include the current and preceding climate. Conservation policies must take into account the fact that any considered ecosystem may be transient and unstable. To be preserved it may be necessary to design against a hostile environment; this requires knowledge of the past, and the present and predictions of the future climates.

The biological sensitivity to climate clearly demonstrates an interdependence between climate and overall biological productivity. There is growing evidence of strong associations between solar radiation and biological productivity (4) and the limiting effects of extremes of temperature and humidity on plant growth are well documented. Climatic factors then are a logical tool for sound management of biological resources on land and enclosed waters.

3. MAN'S IMPACT ON CLIMATE

Man can and does influence climate, sometimes by plan but often inadvertently. Shelter belts such as used on the Canadian Prairies and

in Prince Edward Island to control soil erosion, or to create microclimates favourable for special crops and animals provide examples of control. Significant changes result from the major alteration of the vegetation across a region, such as through extensive development by agriculture in a wild, grassland or forested area; the introduction of drainage systems in marshlands, the flooding of vast tracts of land to provide water for power production or for irrigation. Irrigation itself may cause marked local changes in climate. Water control systems with impoundment, regulation and diversions change the temperature regimes of lakes and estuaries and directly or indirectly influence climate on a local or regional scale. These same technologies may be used to protect an ecosystem from natural ravage, or possibly to create aesthetic areas for tourism or recreation. Most operations of this kind are unfortunately undertaken without due regard to their overall environmental impact, e.g. the destruction of habitats by reservoir operation or drainage.

Man's inadvertent modification of the atmospheric environment through atmospheric pollution is more hazardous in the large scale than that achieved by land-use practices. Most evident in and adjacent to industrial areas, it is nevertheless a global affair. Decreases in solar radiation of about 25 percent have been observed near large industrial centres, but the impact is still significant, although quite diminished, in the Canadian north far removed from industrial centres. For example, Robinson and Robbins (5) observed air arriving over the Greenland ice cap from the American industrial area to have a carbon monoxide content five times greater than that found with other trajectories.

Pollutants which may alter the earth's energy and moisture balance are the most critical on both national and global scales. An increase of 0.2 per cent per year of atmospheric CO_2 has been observed over the past decade (6). Since carbon dioxide plays a significant role in the earth's energy balance (atmospheric warming due to the greenhouse effect) and in photosynthesis, it has both direct and indirect implications to conservation. Atmospheric turbidity has also increased due to industrialization and land-use practices (7). It has direct effects on plant life due to the impingement of fallout of particulate matter on leaves and on the atmosphere by reducing the intensity of the incoming solar beam and the reflectivity of snow fields. Also to be considered are attendant chemical effects, changes in electrical fields, and alterations of the energy distribution within the atmosphere. The increase in cirrus clouds due to jet-aircraft operation acts to reduce the solar energy which reaches the ground. Jet exhaust in the stratosphere may further complicate the atmospheric energy balance.

It should be noted that natural forces such as forest fires, dust storms and volcanic eruptions have always contributed to turbidity, and that volcanoes may result in levels of particulate matter, and gases which exceed substantially those produced by man. The impact of contamination of the above scales, natural or man-induced, cannot be quantitatively stated with certainty, but the associations are identifiable and it would be perilous to ignore these hazards.

Studying the cooling trend which has occurred over the northern hemisphere since 1940, and which has resulted in dramatic increases in arctic pack-ice, Budyko (8) found a corresponding four percent reduction in solar radiation from 1940 to 1960 ($1^{\circ}C$ cooling for each percent reduction) possibly due to increased atmospheric turbidity. Using a schematic-model, Budyko postulated that:

1. There is a possibility of an ice-free regime in the polar basin in our unstable glacial epoch.

2. Glacier expansion could evolve to a critical latitude after which complete glaciation of the earth could occur, i.e. a climatic catastrophe.

3. The input of energy from the burning of fossil fuels may reach sufficient proportions in 200 years' time to offset the reduction in solar radiation.

Slight changes in the energy balance due to man's activities may presumably cause major changes throughout the globe because of the delicate balance of global climate, and the direction of the change is uncertain. The change may destroy permafrost and forests, inundate parts of the continents, and greatly alter life and land forms. It may occur naturally or by inadvertence. Extensive research into the atmosphere-ice-ocean complex is needed to understand and adequately defend against such forces.

Certain areas are more afflicted by pollution than others. The ability of the atmosphere to disperse contaminants depends on ventilation and turbulent diffusion. Some valleys and coastal areas are seriously polluted, not just because of high emission rates but because the topography and climate of the areas impede dispersal. Ecosystems within such sinks may be seriously menaced. Most polar areas are particularly prone to damage through pollution for a variety of reasons, all related to climate. These include the inability of the atmosphere to disperse pollutants because of inversions; the critical equilibrium of life and even of land forms because of the severe yet undependable climatic controls; the inability of the ecology to recover rapidly from damage; and the inability of nature to decompose materials at low temperatures. Thus cold and the vertical temperature structure of the atmosphere of the polar zones result in a serious potential pollution hazard.

4. FUTURE ACTIONS ESSENTIAL FOR CONSERVATION

Knowledge of natural climatic variability and of the impact of man on the environment is essential to rational environmental practices. Climatic interludes and extremes act as powerful biological controls. Their nature, both natural and man-induced must be known; also their impact must be understood quantitatively. Man's impact through atmospheric pollution can be very damaging for two reasons; first of all, pollution may significantly alter regional temperature and moisture regimes to the peril of currently existing ecosystems; secondly, the pollutants transported by the atmosphere may themselves be damaging to living things. The knowledge

requisite for conservation is that which would allow prediction of the possible impact on resources of the natural and modified climate and of airborne pollutants individually, in combination, and in a quantitative manner.

Resolution of the problem is dependent on climatic and bioclimatic research as well as the acquisition of data which is needed for research, research application and control. These actions, combined with an educational system which will ensure a multi-disciplinary approach to conservation, will lead to sound conservation policies and practices, and avoidance of technical inadvertence.

4.1 RESEARCH

Sound conservation practice demands that the ecological effects caused by changes in the atmospheric environment be predictable in a quantitative manner. Many associations have been identified; however the ability to predict changes in a quantitative sense is virtually non-existent. This is partly because of the complexity of environmental problems, partly because of the need for new technologies and partly for want of basic information.

Quantitative prediction will be possible with the development of suitable mathematical models. The application of these models requires basic environmental measurements which identify the climate of each habitat, and the manner in which it is changing or may change. These models must treat with basic controls to productivity such as the heat balance and water balance; with the nature of climatic change; the capacity of the atmosphere to diffuse, transport and deposit contaminants; the response of the species or system to environmental change; as well as social and economic factors. In this way a basis will be provided for policies and their implementation. The studies which are required then include:

1. Determination of the nature and mechanism of climatic change (magnitude, frequency, patterns, controls, etc.) and methods of predicting the impact of change on endangered ecosystems and species as a basis for formulating sound policies for conservation and planning for emergencies.

2. Determination of the amounts of damage or change in ecosystems which may be caused by climatic variations of long or short durations including the influences of pollutants. All critical and major ecosystems and species should be considered in these studies.

3. Determination, quantitatively of the impact on climate, both local and regional, of land-use practices, major engineering developments such as water diversion and control, major industrial complexes, aviation and land travel and similar activities which may alter the atmospheric environment, and thereby earth-bound habitats.

4. Determination of methods of predicting, with acceptable precision, the dispersal by the atmosphere of pollutants, over short and long distances, and the impingement and deposition intensities and patterns.

5. Determination of the capacity of the atmosphere to recover from inadvertent modification or pollution so as to be able to establish safe fetch distances around conserved areas.

6. Identification of phenological and behavioural responses, and of the climatic factors which act as controls to productivity and survival during all developmental or activity periods. At present these are only vaguely understood and this lack of knowledge impedes quantification needed for conservation and management.

7. Microclimatic studies of habitats and immediate environments of endangered systems and species, and the correlations of these results with general climatic factors identifiable by national networks. The need is particularly urgent in arctic areas where survival is continually menaced by the harsh environment, and the delicate equilibrium between climate, vegetation, permafrost, snow and ice fields.

8. Detailed topoclimatological studies of habitats which require special conservation measures.

   Definition of the association between topography and the occurrence of inversion and other weather patterns which may result in pollution crises. These must be defined to provide guidelines for industrialization and emergency action.

9. Development of climatological information for all areas as required for combating disasters such as marine oil spills and the escape of hazardous gases.

10. Determination of the impacts on biota of all possible contaminants so that decisions can be made as to exactly what factors should be measured. The aspects of pollutants working in combination, e.g. a pollutant being ineffective with low humidities, but effective with high humidities and also photo-chemical effects should be explored.

4.2 CLIMATIC NETWORKS

Measurement networks needed for research, monitoring and management should include:

1. Basic climatological stations located in each conservation area, to aid in establishing the dynamics of the ecological system (i.e. whether it is transient or stable because of

climatic forces), to provide a monitor of possible endangerment by climatic (including pollution) change, a basis for transposition of related research results, and a means to estimate potential productivity.

2. Measurement of variations from place to place, in the vertical, and of time variations of all atmospheric factors which may adversely affect, directly or indirectly, a conservation area. This may include measurement of CO_2, temperature inversions and atmospheric turbulence, and other factors critical to an ecosystem.

3. Measurements within areas now damaged by pollution since these measurements may provide valuable quantitative information of the impact of environmental change.

4. Measurement of inversions, turbulence and contaminants in highly populated areas menaced by pollution. Major pollution sinks are often associated with topography which must be considered in the design of such networks. Towers and low-level sondes will form the basis of these measurements.

5. Basic measurements on a grid basis, wherever conservation area networks are inadequate for the general needs of monitoring, prediction and other management practices. All measurement networks must be integrated with other measuring systems to avoid redundancy and waste.

6. Measurements of turbidity, carbon dioxide, and any other factor demonstrated to be capable of significantly altering the regional or global energy and moisture balance. This must be done on a global basis.

4.3 EDUCATION

Knowledge is of little value unless it is exploited. Despite the obvious associations between the atmospheric environment and natural resources, very little use has been made of meteorological information in the management and conservation of resources. University and technical education too frequently treats with ad hoc solutions which serve the purpose of a specific discipline without regard to the impact of these solutions on the total environment. A multi-disciplinary approach is essential if man is to avoid stop-gap solutions which often create new problems, far worse than the original, and resolve the major environmental problems which now threaten. Meteorology has a major role to play in this multi-disciplinary approach because of the importance of climate in environmental processes. Overall education on the complexity and sensitivity of the environment and the merits of taking a total-system approach to the resolution of conservation problems, including the use of meteorology, is an essential, urgent need for our times.

5. SYNOPSIS

1. Climate is a dynamic environmental force upon which biological production is highly dependent! The atmospheric environment includes not only basic atmospheric gases but particulate matter and gases, electricity and vapours which are biologically effective. Some of these components are man-produced and are controllable. But major changes and climatic extremes occur which are not controllable, and these may greatly exceed in impact the effects of man and frustrate conservation efforts. Understanding of the forces which the atmospheric environment may exert is fundamental to the shaping of sound conservation policies.

2. The impacts of climatic variation and modification must be predictable quantitatively. To achieve this, research is needed to show the possible impact of natural and induced climatic change on conserved areas. This requires the study of climatic change of atmospheric transport, of biological response, of the effect of man's technology on the atmosphere, of microclimates of habitats, and of the influence of topography on climate. Pertinent climatological information must also be acquired, analysed and distributed to provide a sound basis of action in the event of emergencies which may threaten conserved areas.

3. The implementation of conservation measures, as well as the undertaking of research, requires the enhancement of current measurement networks. Biological preserves must be established to safeguard unique ecologies. Environmental monitoring stations should be established within each preserve to measure those elements which may endanger the reserve ecologies. Damaged areas should be instrumented to determine impacts of pollution and monitoring networks should be expanded into sparsely settled areas to provide a sound basis for resource management. This should be done as early as possible to ensure future planners an adequate statistical base.

Monitoring, so established, should serve as part of national and global networks, both general purpose and those required to ensure that inadvertent pollution does not significantly alter the global and regional energy and water balance. These will serve research, management and regulatory purposes.

Certain areas act as sumps in which pollutants readily accumulate. Special networks are required in these areas to define pollution hazards and also atmospheric structures and motions. Other configurations of topography and climatic zones which may favour dangerous buildups of contaminants should industrialization occur, must also be identified so as to ensure rational development. Also national climatological analyses must be made to provide a sound basis for designing against such hazards and for emergency measures in the event of accidents.

4. Research should be encouraged in the development of instrumental systems and measuring techniques which will provide the necessary information within the time required. Since access to many conservation areas is difficult, these systems must operate over long periods of time, unattended and under extremes of weather. Also the systems may have to

measure very small differences in contaminant or other levels with precision. Adequate instruments for remote environmental sensing as envisaged here are not available.

5. Finally, an integrated approach must be applied in all conservation and development activities. Climate is a major control on renewal rates of renewable resources, and on the utility of others. It is a major controlling factor on all outdoor activity. Logically then, climatic information should be fully exploited as a basis for decisions in conservation and development. Major development projects such as those which may alter currents may have a profound effect on local or regional climates and, as a consequence, on the ecology of large areas. A thorough, total-systems investigation should precede their implementation.

Integrated planning and development is not likely to be achieved, however, without a change in educational programs. Educators must stress the interdisciplinary aspects of all disciplines which are directly or indirectly treating with the environment. They must also provide positive methods whereby future environmental scientists, planners and engineers may equate atmospheric and ecological change.

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CONSERVATION OF THE CANADIAN TUNDRA

CONTENTS

CONSERVATION OF THE CANADIAN TUNDRA

1. INTRODUCTION

The tundra, lying between the northern limit of the boreal forest and the permanent ice fields of the high arctic, extends over much of Canada's northern territories. This treeless and harsh environment is characterized by a relatively limited number of plant and animal species that function within a complex ecosystem. The tundra flora is comprised mainly of lichens, sedges, mosses and low lying vascular shrubs which have a wide and even circumpolar distribution but there is generally a low level of plant productivity.

The general distribution of wildlife on the tundra shows at least two or more complexes. The first group, represented chiefly by the barren-ground caribou, utilizes the tundra for part of its life or annual cycle and then migrates into the taiga or forest zone during the winter period. Most of the animals' life processes; calving and rutting, as well as the general period of fat accumulation preparatory to winter, take place on the tundra. The muskoxen follow a similar pattern, although in a very reduced form. Muskoxen prefer the lower lush meadows of the river bottoms during the summer and the higher windblown plateaus during the winter but there is no migration or movement into the taiga. Farther north, the arctic island populations are isolated, in contrast to those in the continental area of the tundra, and their movement is restricted by the productivity of any particular island. Throughout most of the tundra, the smaller animal groups, including predators such as the wolf and the polar bear are limited in their distribution based on their major prey species. The polar bear, however, has access to a marine environment which is generally more productive than the terrestrial environment.

This complex tundra ecosystem is considered to be extremely vulnerable to ecological damage, but until recent years it has been relatively undisturbed. The commencement of intensive resource exploration and development activity, however, has accentuated this vulnerability and the prospect of degradation of the tundra or "arctic" environment is now evident.

2. TUNDRA VALUE AND THE IMPACT OF MAN'S ACTIVITIES

The economic structure of northern Canada is geared almost entirely to the development of its natural resources, but this must proceed with a minimal degree of disturbance both to people and to land. Land disturbance has the widest and most visible effect on the tundra because of permafrost and the predominance of non-vascular plants. On the tundra ecological damage may be so easily wrought and the natural environment may be critical to the material and cultural needs of the indigenous people.

There are various ways in which the present level of resource activity is placing stress on the northern natural environment. Exploration for hydrocarbons has traditionally resulted in hundreds or thousands of square miles for every major discovery. A slight disturbance of the thermal

balance of tundra soils can lead to thermal degradation and permanent scars on the landscape, as well as increased erosion and siltation of nearby streams. Mining operations in the North have a generally lesser effect on the land, as they are more localized in nature and confined mainly to the less sensitive Cordillera and Precambrian Shield physiographic regions.

During the summer months, much of the tundra is an impassable morass which precludes, or at least inhibits, ground transportation, but the drier surfaces of the sub-Arctic tundra semi-permanently retain the scars of surface use. Even winter operations are not without their ecological impact because of the sensitivity of plant and animal life to snow cover and density.

Degradation of northern waters is caused partially by the impact of land use, and, more seriously for aquatic life, by the deposition of heavy metals and arsenic from producing mines. Most fish in the far north take longer than their southern counterparts to reach maturity, and are, therefore, exposed to poisonous substances for longer periods of time. The disposal of sanitary sewage in cold northern waters also must be carefully undertaken, to avoid overloading. Selfpurification of water, with respect to organic wastes, is dependent on the rate of energy flow through the aquatic system and the temperatures and shortage of light reduces the effectiveness of this process in Arctic and sub-Arctic regions.

With oil production and transportation becoming major factors in the northern economy, it is recognized that the possibility of oil spills, from wells or pipelines on land, or from tankers in the Northwest Passage, represents the single greatest threat to the northern environment. Also the possible construction of oil and gas pipelines in the North presents a major problem in preserving tundra lands along and adjacent to a pipeline route.

These factors may also alter the traditional ways of the native people by lessening the capability of the land to support them. It must be recognized that northern peoples and particularly the Indians and Eskimos have needs which may not necessarily be met by the development of a viable industrial base.

There can be no doubt that the natural resources of the North must be developed for the benefit of all Canadians, and that resource industries must continue to operate. The problem, therefore, is to allow for industrial activity and economic development, while maintaining environmental quality. This requires a proper balance between preservation, protection, managed-use and restoration of the natural environment which will best serve the material, recreational and perceptive or spiritual needs of the nation and its people. These needs, as an expression of the value of the environment, and the priority of the components of a conservation program, however, may vary from one region of the tundra to another.

In recent years, a shifting sense of values has brought into prespective the social implications of economic development and the

importance of the natural environment to the well-being of the individual and may tend to lessen the importance of material needs. The need for protection of rare and endangered species and the preservation of the tundra as a potential source for recreational use in the future must, therefore, be important elements in any conservation program. Conservation of the tundra is also closely allied with the need for management of certain species such as caribou to provide huntable meat on a sustained yield basis for the use of indigenous people and the sustained yield management of fur-bearers for their economic benefit.

3. PRESENT CONSERVATION EFFORTS

In response to the environmental threat posed by northern development, the Department of Indian Affairs and Northern Development has introduced several new programs to protect the northern and tundra ecology, while still permitting resource development. The Northern Inland Waters Act, passed by Parliament in June, 1970, and the proposed Territorial Land Use Regulations, to be promulgated under authority of the Territorial Lands Act, are designed to ensure managed and orderly utilization of water and land resources, prevention of needless damage to the northern environment and protection for the unique physical characteristics of the region. This legislation also provides for the restoration of damaged lands and the maintenance of acceptable water quality and environmental standards.

As an adjunct to these programs the Department has also implemented an Arctic Land Use Research (ALUR) program to detect and define environmental problems resulting from northern resource development and to devise and test alternate operational procedures which will lessen the risk of environmental damage such as destruction of vegetation cover by oil spills. Scientific projects conducted under this program; such as determination of the effects of oil spills on tundra vegetation, plant regeneration following seismic line disturbance, evaluation of the effects of heavy transportation equipment on the tundra surface, mine waste containment, as well as a number of environmental and resource inventory surveys to establish baseline data, will provide support for environmental legislation. These data will also be used to determine the type and degree of restrictions that should be applied to resource operations to achieve a proper conservation balance; managed-use, restoration, protection and preservation.

In addition to the ALUR projects, other basic research programs dealing with permafrost, primary productivity, distribution and density of terrestrial wildlife and the development of a bio-physical classification for the tundra, are continuing. Hopefully, these efforts will increase man's knowledge and understanding of the tundra ecosystem, and will provide better criteria for legislative action and the identification of areas sensitive to development or in need of preservation.

4. FUTURE ACTION NEED

A sound base now exists for conservation of the tundra environment but achievement of these goals will depend largely on the level

of resources, financial and physical, which the public and private sectors are prepared to devote to them. The growing awareness of the environment and pollution in the populated areas of the south will place demands on our available resources which will surely compete with our needs for northern conservation and national priorities must be established.

To be effective, environmental legislation must be rigorously enforced. In a region as vast as the northern tundra, however, this will require a substantial field organization to provide the necessary surveillance and inspection of resource operations. The Department of Indian Affairs and Northern Development has already enlarged its Resource Management field service in the Territories but with the expected further expansion of resource exploration and development activity, additional increases in staff and funds will be required.

Acceptance of the need for conservation of the tundra environment and the restrictions to be applied on industry will also inevitably increase the cost of resource exploration and production. Major capital investment will be required to meet the demands for resources and conservation, whether from the private or public sectors, and industry and its consumers must be prepared to accept these cost increases.

The tundra and its ability to withstand man's activities is still relatively unknown and the success of conservation efforts will require expanded and continuing research programs, along with acceptance by government, industry and the general public of their responsibilities for the environment.

CONSERVATION OF MUSKEG

CONTENTS

CONSERVATION OF MUSKEG

1. INTRODUCTION

The purpose of this report is to briefly describe the habitat known as muskeg, its value to man in economic, scientific, aesthetic and social terms, the effects of man upon it, current views about its value as a resource and its conservation, present action being taken to preserve muskeg areas and future action needed.

2. DEFINITION AND DESCRIPTION

The word "muskeg" is a term unique to Canada and the Northern U.S.A. It has its origin in the Algonquian linguistic group and represents grassy bog, quaking ground or swamp. In recent years, however, muskeg has become a term designating "organic terrain, the physical condition of which is governed by the structure of the peat it contains, and its related mineral sublayer, considered in relation to topographic features and the surface vegetation with which the peat co-exists" (1). Muskeg represents a condition generally referred to in European countries as "peatland". It consists of a living organic mat of mosses, grasses and/or sedges (with or without tree and shrub growth), which is underlain by a very wet, highly compressible, mixture of partially decomposed and disintegrated organic material (peat). In this environment, therefore, there is a three layered system: a living organic cover, a layer of peat (fossilized vegetation) and a related mineral soil sublayer. The latter may be clay, silt, sand, gravel or even rock. The depth of the peat layer may vary from a few inches to many feet.

Muskeg can and does cover great expanses of terrain (unconfined muskeg or blanket bog) or may be limited to a well-defined area such as a topographic depression (confined muskeg or bog). No accurate figure is available for the extent of muskeg occurrence in Canada, but it is conservatively estimated at 1,295,000 square kilometers (500,000 square miles) (2), or an area slightly larger than area slightly larger than Great Britain, East and West Germany, France and Greece, all combined. Occurring to a greater or lesser degree in every province and territory, muskeg sweeps across a great expanse of the mid Canada region, overlapping the northern forest/tundra zone, the boreal forest, and even occurs sporadically as bogs of varying sizes and types in the southern, more densely populated, region of Canada. The major proportion of the muskeg habitat, however, falls within the subarctic region and within both the continuous and discontinuous permafrost zones.

3. VALUE OF MUSKEG TO MAN

In the past muskeg has not often been thought of as a resource; many who came into contact with it were more prepared to consider it as a blight. Its extent and its existence as a wide swath sweeping across Canada from

east to west, its apparent uselessness and barrenness (in some areas), and its function as a natural barrier to human resource development in the north, has been a source of dismay to some (3). One writer notes that muskeg "just lies there, smeared across Canada like leprosy." (4)

Some thought has been given to how to arrest the development of muskeg. At a Muskeg Conference in 1956 it was pointed out that:

> "Since something drastic.....is required to arrest the accumulation of peat, wishful thinking has turned to the possibility of amelioration through broad environmental changes.....One such method could be fire.....The use of fire alone or in conjunction with drainage and cultivation would appear to present great possibilities......It appears that fire will become the most practical tool in preventing the spread of muskeg conditions even though it cannot be used to reduce materially the depth of peat on present muskeg areas." (5)

Even though this concept is changing, the above view was repeated at the Muskeg Research Conference (6). Current thinking, however, is more favourably disposed towards muskeg as a resource. A considerable amount of Canada's forest resources actually does grow on muskeg. Many muskeg areas have potential as organic soils for agriculture. In Eastern Canada, in particular, muskeg areas are being exploited as a source of peat moss, so necessary in horticulture and to modern suburbia. This is now a multi-million dollar industry in Canada.

Research is underway at the University of Sherbrooke for new uses for peat. This research has indicated great promise for peat in assisting in the clean-up of oil spills on water. Preliminary indications are that peat moss will be effective in clearing water of other pollutants, such as mercury (7). If this project reaches a successful conclusion, the industrial potential of peat moss will expand phenomally, with the concomitant exploitation of muskeg areas rich in sphagnum and hypnum mosses.

Muskeg areas are invaluable scientifically, for the study of northern flora and fauna. Also, the palynologist utilizes a study of muskegs to infer past climatic history of a particular region (8).

Water is one very important aspect of the muskeg resource. There is an increasing need in North America for fresh water, and the question of massive water diversion schemes has been raised, both in Canada and the U.S.A. Addressing himself to the ecological implications of such schemes, Dr. N. W. Radforth has noted that management of northland water would be imposed on a landscape of which about 70 percent of the terrain is organic (9). In these areas, muskeg is the retainer and the delivery mechanism influencing the behaviour of the water supply.

Last, but by no means least, muskeg is a valuable resource in those areas which are a habitat for waterfowl and for waterloving animals, and plays an important part in the conservation of some species of these birds and animals.

4. EFFECTS OF MAN ON MUSKEG

In the southern muskeg areas, near population centres, man's effect on muskeg has been considerable. Confined muskeg areas (bogs) are bisected by roads, railways or hydro lines which affect the drainage pattern and hence the natural ecology. Some areas are utilized for peat moss, a few for agriculture and quite large areas have been affected in the course of forestry development. Near large urban centres, muskeg areas may be utilized as sites for garbage dumps, for shopping centres or housing developments, or even for airports.

As one moves further north, man's overall effect on the resource is much less, even though it is still considerable and will continue to increase. The development of oil and mineral resources since the 1950's and the wide use of soft terrain vehicles has made previously inaccessible muskeg areas highly susceptible to the incursions of man, with the concomitant litter, pollution and general ecological disturbance that accompanies man's "progress". Access roads and railways for development of forestry, mineral and hydropower resources have made their mark on limited areas of the terrain in the subarctic.

One of the major effects of man has been the harvesting of forest resources, which has become increasingly automated and dependent upon the use of off-road vehicles. As noted earlier, some muskeg types do support merchantable tree growth (suitable for pulpwood) and to some extent these have been cut over. Another major effect of man has been in the development of water power, when large areas are flooded. With the proposed James Bay development in Quebec, it is anticipated that this effect of man will be greatly increased, within the next decade.

5. ACTIONS BEING TAKEN TO PRESERVE MUSKEG

The enormous extent of the muskeg resource in Canada, the concept of it being a nuisance rather than a resource, and the immediate requirements of northern development have, until recently, all militated against much concerted action to conserve muskeg in the sense that it required preservation because there was little left. A notable exception to the general rule has been for those often isolated muskeg areas near urban centres. Such bog areas are gradually being destroyed by development of one type or another, by the encroachments of agriculture or of urban sprawl. Conservationists have had to struggle very hard to set aside bog areas because of their importance to local hydrology, or because of special flora which they contain.

Most university biology departments use muskeg areas as field laboratories and attempts are made to have the study areas protected through conservation. As examples, the Mer Bleue bog is used by Carleton University and the University of Ottawa, and protection is sought together with the Ottawa Field-Naturalists' Club and the National Museum. McMaster University is using Copetown bog and the Hamilton area Conservation Authority has extended their protection to this bog. University of Western Ontario is using Byron bog near London and they consider conservation important in terms of protection of environmental quality of that bog. University of Manitoba is using the Delta Marsh which is a conservation area (a wildlife preserve). Several muskeg

areas in Quebec and the Maritimes (and presumably in Western Canada) are used in a similar manner and protection through conservation is actively pursued (10).

For the extensive northern muskeg areas, concern is now becoming centered on the wise use of the terrain. Even here - as in the South - there is some interest in setting aside certain typical muskeg areas to provide reference areas against which to measure changes in the muskeg in developed areas. Efforts in this direction are being made by a small group of people interested in the objectives of Project TELMA of the Commission on Ecology of the International Union for Conservation of Nature and Natural Resources (I.U.C.N.). These objectives are: (a) the preparation of a world list of peatland sites which are of international importance to science, and the promotion of their conservation; and (b) the encouragement of communication and collaboration among research scientists investigating peatlands, particularly in connection with productivity and bioenergetic studies.

Under the direction of Dr. N. W. Radforth of the Muskeg Research Institute, University of New Brunswick, and with the encouragement of the NRC Muskeg Subcommittee, a preliminary selection has been made of 20 site locations in which the vegetation, wildlife and terrain conditions should be set aside for reference in research, as lands are developed (11). These areas are representative of the arctic archipelago, tundra (mainland), forest-tundra transition, boreal forest and the southern reaches of Canada, and include the maritime and continental climatic influence. This list of sites has not yet been published and has, of course, no official status as yet.

Because of lack of funds, Project TELMA (Canada) has associated with the International Biological Program, in particular the Conservation of Terrestrial Communities with the program (IBP(CT) and studies are progressing, largely through the Muskeg Research Institute. Through joint funding by IBP(CT) and MRI, association with international interest and study is being developed with peatland conservation experts in the U.K. and Finland.

Other institutes such as the Boreal Institute at Edmonton, and the Institute of Northern Studies at Saskatoon are also including muskeg conservation in their programs.

The National and Historic Parks Branch of the Department of Indian Affairs and Northern Development is keenly aware of muskeg conservation and such areas are fully protected in Canada's National Parks. Point Pelee might be an appropriate example where the marsh area has full protection. The situation in Provincial Parks is much the same and muskeg conservation is actively practised in the Algonquin and Quetico Parks, Ontario.

Also, at the governmental level, the Canadian Wildlife Service (Department of Fisheries and Forestry) is well aware of muskeg conservation, at least in selected areas, as part of their program related to environmental quality and protection of natural areas. The National Advisory Committee on

Water Resources Research has indicated their awareness of muskeg conservation in the context of water resources.

In Canada, however, there is little effective legislation pertinent to muskeg conservation, except for the small local areas and the National and Provincial Parks mentioned above.

6. FUTURE ACTION NEEDED

More vigorous action is needed to conserve confined muskeg (bog) areas near urban centres (particularly university centres) and protect them from the encroachments of housing developments and garbage disposal sites, or use as a source of peat moss. Such areas are invaluable for field studies by students of palaeobotany, palynology, ecology, etc. as well as for all naturalists both professional and amateur. Provincial governments should be provided with adequate scientific information to assist them to make the sometimes difficult political decision to declare a particular muskeg area as a conservation area.

The Project TELMA/IBP(CT) concept should be encouraged through additional funding, the reference sites identified, and action taken to have these areas set aside as reference areas. An active research program should then be undertaken to acquire the base reference data at each site before northern development expands to a point where these areas can become indirectly affected by man, e.g. by air pollution. For each area studied, a sum of at least $20,000 per year would be required for the next 10-15 years. A national committee should be set up to monitor these reference areas over the years to watch for any undue encroachment on them.

The need to protect the muskeg environment was reinforced by the Science Council of Canada Report on Research in the Earth Sciences (12). This report says, in part:

> ".....Canada is currently facing a critical need for land use planning in the permafrost and muskeg areas of the Arctic. The rapidly increasing rate of petroleum exploration is forcing the implementation of political and technical decisions without an adequate background of scientific knowledge and experience..... The Science Council endorses the conclusions of the Study Group that increased emphasis must be given to northern terrain studies."

7. SYNOPSIS

1. At least 1,295,000 sq. km. (500,000 sq. mi.) of the terrain in Canada is covered with muskeg, or organic terrain, an environment consisting of a three layered system: (a) a living organic cover, (b) a layer of peat, and (c) a related mineral soil sublayer. Muskeg sweeps across the breadth of Canada in a wide swath and occurs in every province and territory.

2. Until recently, its value to man was considered to be very dubious indeed. The southern fringe areas have been utilized to a small extent for agriculture or for mining of peat moss. The value of some muskeg areas as a source of merchantable timber is now being realized. The most

important aspect of the great expanses of northern muskeg is its function as a great storage reservoir for fresh water, a commodity which is becoming more and more scarce in North America. Other values include, wildlife habitat, possible use in assisting in cleaning of oil spills on water, and scientific aspects (biota, palynology).

(3) The effect of man on muskeg is a function of its remoteness from population centres. Development of oil and mineral resources in the north has had some effect but to date this has not been serious. Southern bog areas, on the other hand, are threatened by man as are all other natural areas.

(4) Interest in muskeg conservation has been minimal, due to its great extent. Some work is being done in identifying typical muskeg sites that can be set aside as future reference sites, through the Project TELMA and IBP(CT) program. This effort should be encouraged, expanded, and accelerated through more funding.

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FOREST CONSERVATION IN CANADA

CONTENTS

FOREST CONSERVATION IN CANADA

1. INTRODUCTION

The purpose of this report is to describe briefly the forest resource of Canada, its value to man, the effects of man upon it, steps being taken to preserve the resource, the adequacy of these steps, and future action needed. The scope of the paper includes forests and areas of transition between forests and other biomes. The conservation of soils, gene pools and water resources are dealt elsewhere in the Canadian reports and will not be discussed here in any detail.

It is assumed that forest conservation includes both the maintenance and improvement of the full diversity and potential of the forest by wise land use and management, and the preservation and management of particular sites to retain one or more specific characteristics of scenic, recreational, educational or scientific interest.

In the text the term "billion" is used in the North American sense of one thousand million (i.e. 10^9).

2. DESCRIPTION OF THE FOREST RESOURCE

2.1 AREA

Forests cover 48% of Canada's 9.20 million sq. kilometers (3.56 million sq. miles) of land surface. About 55% of this forest land is productive, i.e. capable of producing merchantable wood; the remainder includes 68,900 sq. kilometers (26,500 sq. miles) of forest set aside for National and Provincial Parks, game reserves, and watershed preservation. More than half the productive forest land is located in the provinces of Quebec, Ontario, and British Columbia (11, 12).

2.2 OWNERSHIP & RESPONSIBILITY

About 91% of the productive forest land is in the possession of the Crown in the right of the federal (9%) and provincial governments (82%); corporations and private individuals own the rest (9%). Rights to cut Crown timber under lease or license have been granted on 23% of the productive forest land. Woodlots on farms comprise about 3% of the total productive forests (11, 12).

The role of the provinces and land tenure systems vary from one province to another. Most provinces have the responsibility for the protection of the forest. In some cases the provincial government is responsible for restocking felled areas (e.g. Ontario), in others regeneration of cut areas is the industry's responsibility (e.g. British Columbia), and sometimes the responsibility is shared (e.g. Quebec).

As regards the non-productive forest land, again most is Crown land in the right of the provincial and federal governments. Although most of this land is under the jurisdiction of the provincial governments, the federal government has jurisdiction over considerable areas of forest

in the Northwest and Yukon Territories.

International forestry matters are the responsibility of the federal government.

2.3 VEGETATION

Canada's forests are very varied and grow on many types of soil in many climates. The forests have been classified into eight Forest Regions (27); the distribution of these regions and their characteristic species are given in Figure 1. In general the forests are mainly coniferous, and include 31 coniferous tree species and over 100 deciduous species (17). Some of these species extent into the United States and forests of the two countries are often continuous.

Canadian forests occupy land which has only been freed from glaciers for a few millennia. Some tree species apparently have not attained their potential distribution range and are still extending their limits (24). In this process new contacts between closely related species are resulting in hybridization and evolution of new types.

Most of the forests are of natural origin; less than 2% of the productive forest area has been planted or seeded by man (13). Some of the natural forests have been exploited, but vast areas remain relatively undisturbed by man. The diversity of these forests is reflected by the diversity of the wildlife populations they support.

2.4 FOREST WILDLIFE

The forest mammals of Canada provide by far the largest economic and aesthetic benefit to Canadians than those from any other biome, largely because the forested area covers a large part of Canada and mammal productivity is high. The mammals thrive when forests are wisely managed and in hinterland areas where the forests provide food and cover. The mammals provide economic benefit through harvesting of fur species or big game as a vocation or a sport.

This report discusses wildlife as part of the forest resource equation and in an evolutionary sense; both forests and mammals have evolved together. Although forest mammals damage trees, this is a natural process.

The numerous forest biomes found in Canada (27) (Figure 1) generally contain a specific fauna peculiar to the biome. These are listed as follows:

I Boreal - Characteristic mammals are the moose, woodland caribou, barren-ground caribou (seasonally), black bear, grizzly bear (western and northern), deer (mule deer and white-tail) mountain sheep, mountain goat and the fur-bearers, beaver, fisher, fox, lynx, marten, mink, muskrat, otter, skunk, squirrel, ermine and wolverine.

II Subalpine - The major mammal species are moose, mule deer, white-tail deer, wapiti, mountain sheep, mountain goat, woodland caribou, grizzly bear, black bear, mountain lion and the fur-bearers, beaver, fisher, mink, otter, squirrel and wolverine.

III Montane - A relatively small section similar in floral components to the above.

IV Coast - Mammals include those in (II) and (III) except the black-tailed deer is substituted for the others and the bobcat replaces the lynx.

V Columbia - animals as in (II) and (III).

VI Deciduous - The larger mammal species are rare.

VII Great Lakes - Mammals are chiefly moose, (northern section) white-tailed deer, black bear, and fur-bearers fox, lynx, bobcat, beaver, otter, fisher, mink, marten, muskrat and the racoon.

VIII Acadian - Mammals are chiefly moose, caribou, white-tailed deer, beaver, mink, marten, fisher, otter, lynx, bobcat, red fox.

3. VALUE OF THE FOREST RESOURCE TO MAN

3.1 FOREST PRODUCTS

Canada's forests contain about 21 billion cubic meters (749 billion cubic feet) of timber (12). The forest products industry employs directly about 4.5% of the total Canadian labour force (and indirectly much more), accounting for 5% of the Gross Domestic Product and 22% of Canada's foreign exchange (2,22). It is one of Canada's main industries.

3.2 WILDLIFE

Animals provide provincial and territorial governments with revenue from hunting and trapping licences. Hunters number over 100,000 Canadians. Revenues from trapping amount to about $12,000,000 per annum (20) and about 40,000 full-time or part-time trappers are involved (25). Wild fur prices are at present generally depressed, thus reducing and discouraging the take of an increasing resource.

3.3 TOURISM & RECREATION

In recent years from 35 to 40 million people (nearly twice the Canadian population) visited Canada annually from the United States; these tourists spent from 0.7 to 1.2 billion dollars per annum (11). Canadians probably spend a great deal more than this on recreation, but no precise figures are available. Many people undoubtedly visit Canada for its unique forest landscape and associated rivers and lakes; it is probably conservative to attribute half of the tourist revenue to this landscape. The forest is also of incalculable benefit to the mental and physical health of the Canadian people. A great many Canadians participate in some form of outdoor recreation in the forests and their associated rivers and lakes. A by-products of the recreation is the support of a

thriving sporting equipment industry.

3.4 WATERSHED MANAGEMENT

The value of the water resources is described elsewhere. Here it suffices to say that maintenance and management of a forest cover is necessary to stabilize soil on catchment areas and regulate the run-off so as to give an adequate water yield and yet minimize the risk of flash floods. This particularly applies to the steep catchments of the eastern Rocky Mountains.

3.5 SCIENTIFIC VALUE

In spite of extensive utilization by man, most of Canada's forests consist of natural tree populations which have not been altered a great deal by man. Large tracts are still accessible only with difficulty as roads are few. As already mentioned, many trees reach the limits of their natural distribution in Canada and some populations are still evolving. These features, together with the enormously varied rock, soil and climate, make Canada's forests one of the major scientific resources of the world. The natural forest affords opportunities to study the variation and dynamics of tree and wildlife populations, tree succession and competition, the genetics of natural populations, effects of forest practices and natural catastrophes such as fire and insect attack, migration mechanisms of trees, the evolution of introgressed populations, the behaviour of trees at the edges of their distributions, and the processes of natural ecosystems. Such studies are not only of academic interest; they will provide a basis for ecologically sound management to the greater total benefit of mankind.

4. EFFECT OF MAN ON THE FOREST RESOURCE

4.1 COLONIZATION & DEVELOPMENT

The early development of Canada involved great hardship and this influenced the attitudes of the people toward the forest. The supply of timber and wildlife seemed inexhaustible to the early settler and forester, and little thought was given to replacing what was taken out. To the farmers in some areas the forest was an enemy to be kept at bay, even though clearing timber provided building materials and an income. These attitudes are changing, but they must be taken into account when considering the conservation of forests.

Only within the last three or four decades has Canada become an industrial nation, and her industry is still concentrated in relatively few areas. Before settlement by Europeans, the indigenous peoples did not greatly affect the forest. They may have been responsible for burning tracts of forests, but nature also does this on a grand scale. The early settlement of Canada by Europeans was along major rivers and lakes, and early exploitation consisted mainly of trapping fur bearing animals, clearing forests for farming, and timber acquisition. The trapping did not greatly affect the forest vegetation. Soils on the farms were often shallow or infertile, particularly on the Canadian Shield, and many unsuccessful farms were abandoned and re-invaded by trees. The export timber trade developed in the early 19th century and initially concentrated in the Maritimes and on

the large red and white pines of the Ottawa Valley, later extending to other areas (e.g. the West Coast) and other tree species.

Even today Canada has only been developed along a relatively narrow east-west 240 to 320 kilometer (150 to 200 mile) wide band to the south. Outside this belt, the climate and landscape are often inhospitable, and development has been sporadic. The timber trade has increased in intensity in recent years and the discovery of new natural resources such as metal ores, oil and gas has stimulated man to penetrate further into the northern forests. Air transport has made remote areas more accessible, and it is inevitable that pressures on the northern forests will increase

4.2 FOREST MANAGEMENT

In the early days following settlement, the emphasis was on utilization of the forests and removal of the best trees with no heed for genetic or ecological consequences. The resource is still being utilized, but there is now concern for the effects of forest management. The earliest management of forest was mainly concerned with protection. Cutting of pine for ships masts was restricted (15) and sites capable of growing such pine were preserved by the British Government as early as 1729, albeit not with much success. Regulations against forest fire were made in Newfoundland in 1610, Nova Scotia in 1761 and New Brunswick in 1784. This was followed by regulation of cut in an attempt to achieve sustained yield, and foresters now aim at the resource conservation by good management. Although forestry involves tree harvest and forest disturbance, it is in the interests of society to preserve the resource's full potential. Although locally forest resources, and in some cases particular tree species, are being cut at a rate that is greater than the local allowable cut, on a national scale..... the maximum allowable cut of 0.34 billion cu. meters (12 billion cu. feet) was estimated to be almost four times the annual harvest in 1965 (16). It has been predicted, however, that by the year 2000 total demand will approach this figure. At present foresters are attempting to restock areas at the same rate as they are felled. About 800,000 hectares (2 million acres) of forest are harvested annually in Canada; most of this (87%) consists of clear cuts and the rest selection (12%) and other types of cut (1%). About 680,000 hectares (1.7 million acres) of forest are regenerated annually by natural (69%) and artificial (14%) means, but the remaining 17% remain inadequately stocked. This does not include the 880,000 hectares (2.2 million acres) burned annually, a great deal of which may be regenerated but not always by the species the forester wants. More serious is the backlog of 16.8 million hectares (42 million acres) of forest land which, in the forestry sense, remains inadequately regenerated following felling, fire and unsuccessful attempts at farming; these areas may support at least a small tree population.

Forest management preserves the productive forest resource, but often changes the forest from its original natural state. Fellings alter the stand geometry and, if they are selective, possibly the gene complement. Any felling inevitably affects the microclimate, the populations of wildlife and lesser vegetation and soil organism activity. Harvesting trees involves road building and creation of new plant migration routes, use of heavy machinery compacts the soil, skidding out logs disturbs the upper soil profiles, and removal of timber may mean loss of nutrients from the site.

When using natural regeneration a forester will favour trees of economic importance and may thereby influence natural succession; if he plants or seeds the area he will change natural succession, and may alter the forests' genetic composition by introducing new genetic material.

Site preparation by burning, scarification or ploughing may be needed before planting and seeding, all of which affect the microclimate, soil vegetation and wildlife. Herbicides are often used to impede development of competing vegetation, insecticides to control insect populations, fertilizers to stimulate tree growth, and fire retardants to control fires. All these practices affect forest plants, animals or soils. Some of these effects may be ephemeral, others may be long lasting; some are of little importance on a national scale but may have considerable local impact.

Forest mammals are mobile, and with present management techniques being used where the goal is maximum sustained yield, exploited populations are not in danger. However, with increased development, habitat destruction is occurring at a rapid rate. This includes river valleys productive of wildlife lost to hydro-electric projects, strip-mining, agriculture, mineral and oil exploration and industrial pollution. Coupled with this are ill-advised predator control programs which upset the natural balance. It is axiomatic that when the habitat for wildlife is eroded it indicates that the habitat is also untenable for man in the long term unless artificial structures are created which may have limited aesthetic value.

The immediate effects of some current forest management practices are obvious, and there is a certain amount of evidence in the literature which gives us a clue to the effects of others. Very little is known, however, about the long term effects of forest management practices on the many components of forest ecosystems in Canadian conditions.

4.3 MINING & OTHER HEAVY INDUSTRY

The operation of heavy industry is associated with local air and water pollution. Standards and controls of gaseous emissions and water effluents set by the federal and provincial governments will restrict these effects.

The mining and smelting of ores has had considerable local effect upon forest vegetation. In some areas (e.g. Sudbury, Ontario, Wawa, Ontario, Trail, B.C.) the vegetation has been damaged over radii of 40 to 80 kilometers (25 to 50 miles) from the source of air pollution, but in relation to the total forest area of Canada the affected areas are at present small. Mineral deposits are still being found, and it is quite possible that valuable ores may be located in valuable forests, creating a conflict of interests and a need for designation of priorities. This is a factor to be borne in mind when the possibility of reserving forests for recreation or science is under consideration.

4.4 RECREATION

Canadians are free to roam most of the country's forests as far as the difficulties of access will permit. It is, of course, necessary to

comply with the laws governing fish, game and forest protection, but restrictions are remarkable few compared with those necessary in more densely populated countries. Many regard the recreational resources of Canada as unlimited. Taking the country as a whole there are about 52 hectares (130 acres) per capita. Much of this land, hoever, is poorly accessible. On the basis of moderately accessible land of good recreation potential, there are about 12 hectares (30 acres) available per capita (6). The demands for recreation are increasing; for example in the period 1950-65 there was a five-fold increase in visitors to National Parks (14).

When people visit the forests and their associated lakes and rivers for recreation, they either use the resource as it is without man-made facilities, or concentrate in areas where facilities are provided. Usually the greatest impact by trampling, breakage and litter is in the latter areas. Some recreation is strictly seasonal; and until recently few people penetrated far into the forests for pleasure in winter. Not a great deal is known about the effects of recreational activities on the forest soils, vegetation and wildlife, but fires caused by recreation are of considerable importance. About one quarter of the 7500 or more fires which annually destroy about 1.0 million hectares (2.5 million acres) of Canada's forests annually are attributable to recreation. Fires caused by recreation tend to be more localized than fires from other causes, and account for 9% of the total area burned each year, and cost the country at least $4.6 million dollars annually for total damage and fire control costs. This is quite apart from possible effects on soil and site quality, and temporary effects on wild life, scenic and recreation values (19). In the case of sport hunting, hunters are increasing in number and are penetrating both crown and leased lands (18).

4.5 INTRODUCTION OF INSECTS & DISEASES

The intercontinental movement of trees and forest products has led to the introduction into Canada of serious forest insects and diseases. This has led to widestread destruction of spruce, white pine, true furs, larch, beech, and dutch elm. In some areas such introductions have eliminated white pine as a commercial species, and from the late 1930's to the early 1940's about 19.6 million cubic meters (700 million cubic feet) of merchantable spruce were killed.

5. MEASURES TAKEN TO MAINTAIN THE FOREST RESOURCE

Canadians have tackled forest conservation problems on a broad front. In general the history of forest conservation in Canada has followed the sequence of protection of the forests from fire, forest inventory, protection from insects, regulation of cut in an attempt to achieve sustained yield, regeneration of forest, site reservation for scenic and recreational values, and finally the relatively new phase of reservation for maintenance of natural conditions and scientific purposes. The time scale and details of sequence vary from one province to another.

Forest conservation, therefore, is practised in both its main aspects; firstly in the maintenance of the resources by protection and cut regulation for sustained yield (i.e. by good management), and secondly in site

reservation and management for purposes such as scenic value, recreation, education, and science.

5.1 RESOURCE MAINTENANCE BY GOOD MANAGEMENT

Resource maintenance and the necessary inventory, education, research and legislation needed to support it are the responsibility of the federal and provincial governments. Although timber limits may be leased to the forest industry, the provincial governments are able to specify and regulate the cut. Where the province is responsible for planting or seeding cut areas, they are able to control the seed source used and avoid some anomalies of the past.

The federal Canadian Forestry Service carries out research on forestry problems which are specific to particular regions as well as on matters of national concern. This research has been in progress for many years and includes studies of protection from fire, insects and diseases, tree yield, plantation establishment and natural regeneration, effects of trees on water catchments, forest management methods, problems of soil fertilization, forest products, population studies, genetics, rules of seed transfer, forest processes, ecological effects of forest management practices, economics and many other topics. The objective is to provide the knowledge needed for efficient resource management and maintenance. The Canadian Forestry Service is also responsible for the certification of seed moving in international trade.

A great deal of this work is done in co-operation with the provincial governments and the forest industry. Regional federal research programs are developed in conjunction with provincial forestry organizations.

The federal Department of Regional Economic Expansion is involved in the financial support of rehabilitation of small woodlands, regeneration and forest improvement in some provinces particularly in eastern Canada.

The federal government, through the Department of Indian Affairs and Northern Development, is responsible for land use regulation in the forests of the Northwest and Yukon Territories. These regulations (in the Forest Protection Ordinances of 1956 and 1958) mainly concern protection from fire and insects, sale of land, and use of the forest.

Federal legislation has also been enacted to protect forests on water catchments of the eastern Rocky Mountains (Eastern Rocky Mountain Forest Conservation Act 1947). This Act established a joint federal-provincial board to protect the forests on the catchments and manage the forest to give the optimum flow in the Saskatchewan River and its tributaries.

The federal government is responsible for the enforcement of legislation relating to tree plant and seed movement between Canada and other countries. Federal legislation and regulations are at present being formulated. At present tree material coming into Canada needs an import permit from the Canada Department of Agriculture. Each import must be at an approved port of entry and be accompanied by a certificate of inspection from the country

of origin. The importation of plants and seeds of some tree and shrub species is prohibited or restricted, but this varies from one province to another. Tree plants and seeds exported from Canada need a phytosanitary certificate from the Canada Department of Agriculture. These regulations are necessary to prevent the import of serious pests; as described earlier, Canada's forests have suffered heavily from such imported pests in the past. To minimize the risk of dangerous introductions and to minimize the losses from introduced pests, procedures such as the following are being practised in Canada: the exchange of information on insects and diseases with other countries through such agencies as the International Union of Forest Research Organizations (IUFRO) and the Food and Agriculture Organization; (FAO) based on this information and recommendations by such agencies, maintenance of an annual survey of forest insects and diseases aimed at the early detection of introduced pests; and the introduction and release of predators and parasites as a control measure against introduced insects. Within North America, tree material movement between Canada, the United States and Mexico is controlled in cooperation with the North American Forestry Commission (FAO).

It is also the concern of federal and provincial governments to maintain the populations of wildlife in forests. Most provinces are actively concerned in wildlife management, and some are carrying out related research. The federal Canadian Wildlife Service carries out research on the relationship between wildlife and forests and factors affecting the health of wildlife populations. It also supports research and management relating to wide-ranging wildlife populations, and attempts to prevent the extinction of any animal (4). Where animal species are hunted or trapped under licence the populations are managed well except in hinterland areas. The provincial and territorial game administrations follow modern management techniques and no harvestable species are in danger. Such conservation practices are strengthened by a significant research effort. Generally, this management includes bag limits, seasons, and complete closure to hunting or trapping when a species is threatened in any local area. Forest species not regarded as game are generally not protected, and it is in this area that further initiative must be taken. Populations of some species are protected in National Parks, Provincial Parks and in game preserves. Some protection is also afforded by Canadian law in that trespass on private property to hunt game can be prohibited by individuals, so that in general permissive use of the resource is prevented. There is some liberalization of legislation with respect to hunting for food by the indigenous peoples of Canada who retain privileges in this respect by treaty. The emphasis of wildlife conservation in Canadian forests has been mainly on fauna valuable as game or fur producers, with less emphasis on other fauna such as passerine birds. The Federal Government, in cooperation with other agencies, also administers programs, agreements and acts relating to the fauna of forests and other types of habitat (e.g. Migratory Birds Convention Act, Wildlife Inventory Program, Caribou Inventory, and Fur Conservation Agreements (11).

Many of the provincial governments are actively involved in forest research (including protection, regeneration, fertilization, genetics, recreation, wildlife management and economics) in support of forest conservation programs. Some of this work is in cooperation with both the federal government and the forest industry.

5.2 FOREST RESERVATION

Relatively large areas of forests have been reserved for specific purposes since the late 19th century (11). This has evolved into a complex system of site reservation for many purposes such as education, history, recreation and scientific interest. The present emphasis is on reservation of forests for recreation, but in the past few years there has been an increase in reservation for scientific interest. The new Ecological Reserves Act being processed in British Columbia reflects this interest.

Forest reservation is mainly carried out within the parks system. More recently forests have been reserved in cooperation with the International Biological Program Conservation Sub-Committee (IBP/CT) which is concerned with site reservation for scientific purposes (23). The federal National Parks have a uniform policy throughout Canada (7), but Provincial Parks (and allied game reserves and recreation areas) are governed by policies which very from one province to another (1,2,3,5,8,9).

The federal National Parks preserve sites for the benefit, education and enjoyment of the people of Canada. The National Parks Act of 1930 and its subsequent amendments instructs that these parks are to be left unimpaired for future generations' enjoyment. The policy, as it relates to forest land, is to maintain the scenic and recreational facility with minimum disturbance of natural features. Maintenance fellings in parks for fire and erosion control and maintenance of forest health, and the culling of wildlife populations are kept to a minimum. Fishing is permitted, but hunting is not. Limited scientific research is permitted in National Parks when no other sites are available, but no industrial activities are permitted. Public appreciation of nature is developed by exhibits, lectures, trails and leaflets (7). The emphasis is on preservation for recreation.

There are 24 National Parks covering 76,211 sq. kilometers (29,425 sq. miles). More, with a total area of about 7,770 sq. kilometers (3,000 sq. miles) are in the process of establishment. The individual size of these parks varies from a few hundred acres to 44,800 sq. kilometers (17,300 sq. miles). Some of the larger forested parks are from 5,180 to 10,360 sq. kilometers (2,000 to 4,000 sq. miles) in extent. The main forested National Parks are concentrated in the north and west of Canada, with few in the southern, central and eastern parts of Canada (11).

There are 1814 Provincial Parks in Canada, and this number is continually increasing. These parks cover 249,000 sq. kilometers (96,000 sq. miles) and the larger ones are up to 18,200 sq. kilometers (7,000 sq. miles) in extent. Many of the larger Provincial Parks are at least partly forested (11). The coverage tends to be irregular, but many forest types are represented from southern Canada up to the forest-tundra transition in the north. Although the objectives and land use of these parks varies within and between provinces, the principle objective is to reserve land for recreation. Some sites, however, are being preserved for scientific purposes, and this kind of reservation is on the increase. Many provincial governments recognize the need for maintaining natural areas, and wilderness areas of considerable extent have been established. Some of these may have recreational value, but others are so remote and difficult to reach that recreational impact is not likely to be great for some years.

Most provinces have some form of park classification. This classification may be simple or two-tiered. For example, Ontario (3) recognizes primitive, natural, environmental, wild river, nature reserves and recreation parks, each with different defined objectives, Within these classes are five possible zones based on use, i.e. primitive, natural, historic, multiple use and recreation. Ontario also recognizes a Recreational Reserve class. British Columbia (2) recognizes three main classes of park; A parks -- to preserve sites of outstanding scenic and historic interest for recreation, B parks -- to protect natural attractions but permit other resource uses, C parks -- for local residents. In any of these parks there may be nature conservation areas. Alberta (9) has seven classes of park (wilderness, historical, ethnological, archaeological, natural environment, recreation, specialized outdoor recreation, parkways, and commission) and three possible types of use (scientific study and recreation, mainly recreation, multi-purpose) i.e. a total of 21 categories. Each province has its own system (5,8) but the overall emphasis is on provision of recreation.

One difference between forested national and provincial parks is that in the former no commercial timber harvesting is permitted, while commercial logging is permitted in some provincial parks provided that it follows certain prescriptions. Park logging has been the subject of considerable public concern and discussion.

The Canadian Institute of Forestry has formed a Natural Areas Committee and recognizes the value of such areas as living museums, outdoor laboratories, outdoor classrooms and benchmarks for studies of effects of forest practices. It is anticipated that this committee will review applications for establishment of natural areas, and work in cooperation with other bodies (such as IBP/CT and the Society of American Foresters) involved in conservation (29).

6. ADEQUACY OF PRESENT FOREST CONSERVATION POLICY & ACTIVITIES

Canadian forest conservation activity covers attempts to maintain the resource by good management and the reservation of sites for recreation and scientific purposes.

The resource maintenance aspect is being treated in depth and considerable efforts have been made by federal and provincial governments as well as the forest industry to protect the forest and sustain the yield. On a national scale current harvesting is below the allowable cut, and annual regeneration is lagging not too far behind felling, but locally the harvest exceeds allowable cut. There is, however, a vast backlog of previously burned or exploited land which still has not been successfully regenerated in the forestry sense, and every effort should be made to get those sites with the necessary potential back into wood production. The logging activities are the source of public concern, particularly where extensive clear cuts are used; at present this concern is less apparent in Canada than in the United States. The Canadian Forestry Association and allied organizations have been active for many years in informing the public about forestry matters. There is, however, on concerted effort in Canada to study the reactions of the public to different silvicultural and logging practices, nor to convey to the public the necessity for these practices, and the often temporary nature of the scars on the landscape. Not a great

deal of research has been done on the practicability of using alternative silvicultural treatments in accessible sensitive areas of scenic beauty.

A great deal is known about effects of forestry practices on timber yield, and tree succession but very little is known about the scale and duration of the effects on the other forest ecosystem components (soil, wildlife, micro-climate) (24), or the effect upon the forest biome of increasing recreational pressures. Research on these topics is necessary if the forests are to be managed efficiently to retain their numerous facets which are of value to man.

Many foresters are mainly concerned with forest management for timber yield and only comparatively recently has forestry education included the broadly based ecological approach, taking cognizance of the relationship between the trees and other components of the biome. There is a need for the inclusion in forestry education of more courses relevant to conservation in its broad sense. There is also a need to inform the public to a greater extent about the objectives of forest conservation.

The numerous National and Provincial Parks cover a wide ecological spectrum and are a major contribution towards the preservation of man's natural heritage. There is, however, no systematic reservation of the main forest types or systematic setting aside of forests of special scientific interest, such as those populations still evolving or migrating. Although there are many management policies suited to local needs or the needs of a particular type of park, we still know very little about how to manage natural forests to keep their full biological diversity and character. If natural destructive processes such as fire and insect attack (which are responsible for the regeneration and succession of forests) are controlled, how far should natural areas be managed by cutting to achieve the desired structure? This is only one of the many unanswered questions, and we do not even always know what the desired natural structure should be. There is, therefore, a need for a systematic coverage of forest sites for scientic purposes, and for the development of a management philosophy and policy for natural or wilderness areas.

7. FUTURE ACTION NEEDED

7.1 POLICY, PRIORITIES & LEGISLATION

I Development of a national forest conservation policy and philosophy covering the maintenance by good management of the many facets of the forest that are of value to man as well as forest reservation for scientific, cultural and recreation purposes

II Designation of national priorities for site reservation taking into account the sensitivity of sites to degradation, the immediacy of danger of destruction, their scarcity, economic, scientific and social values, and the practicability of reservation and subsequent management, and the systematic reservation of forest land.

III Re-examination of the current legislation governing land use and the conservation activities of both federal and provincial organizations to discover whether the legislation should be modified to make it possible for these organizations to play a more active role in conservation in keeping with the needs of today.

IV Consideration of ways of integrating the programs of organizations concerned with conservation of different components of the forest biome and the associated research, so that an overall forest conservation philosophy can be developed. This particularly applies to forest reservation for non-consumptive uses.

V Investigation of ways of increasing cooperation in forest conservation programs with the United States Government, particularly where these programs concern tree species, forest wildlife and forest ecosystems common to Canada and the United States, and species which reach their northern and southern limits in these respective countries.

VI Strengthening international regulations concerning import and export of trees and plants so that risks of importing pathogens can be reduced.

VII Added initiatives in terms of legislation, research and management are needed to preserve, rehabilitate and conserve rare and endangered animal species in Canada.

7.2 EDUCATION

There is a need to inform and educate the public in the aims of, need for and value of conservation in its widest sense in simple terms. Education should be at all levels (schools, universities, the press, radio, television and at recreational centres), and subjects relevant to all aspects of forest conservation should be given greater emphasis in forestry school curricula.

7.3 RESEARCH

There is a need for:

I Identification of tree and wildlife species and forest ecosystems of particular scientific interest, particularly where the species or ecosystems are in danger of destruction or attrition by the increasing activity of man.

II Studies of the effects of forest practices and natural phenomenon such as fire and insect attack on the different components of forest ecosystems to provide an ecological basis for sound management practices.

III Investigation of the dynamics and diversity of populations of plants and animals in forests to provide a sound basis for conservation policies and management.

IV Investigation of ways of managing non-reserved forests near roads and recreation centres in such a way that consumptive forest use does not conflict unduly with aesthetic and recreational values.

V Investigation of the relationship between the public and the forest, particularly the impact of increasing recreation pressures on both reserved and non-reserved forest.

VI Investigation of the economic value of the forest in its role of a recreation facility so that the value of this role can be quantified and its importance in the national economy defined.

8. SYNOPSIS

I Forest conservation activities in Canada fall into two categories, I the maintenance of the resource by protection and wise management, and II the reservation of forests for specific purposes such as scenery, recreation, education and science by limitation of land use.

II Forests cover 48% of Canada's 9.20 million sq. kilometers (3.56 million sq. miles) of land surface, and about half of this is productive, 68,900 sq. kilometers (26,500 sq. miles) of forest have been reserved for parks, game reserves and watershed preservation. Less than 2% of the productive forest has been planted and seeded by man. The forests support a numerous and diverse animal population of great economic and aesthetic benefit to Canadians.

III The forests contain about 21 billion cubic meters (749 billion cubic feet) of timber, and are the basis of the forest products industry which is one of Canada's main sources of wealth. The wood-based industry employs 4.5% of the labour force directly, and accounts for 22% of the country's foreign exchange. The revenues from tourism associated with forests are considerable. The forests are also of great scientific interest and include tree populations still in the process of evolution.

IV The forests are maintained by regulation of cut for sustained yield, regeneration of felled and burned areas, and protection from fire and insects. Regeneration is lagging a little (17%) behind harvest at present, and there is a backlog of 16.8 million hectares (42 million acres) felled or burned early in the century which remain inadequately stocked.

V Although locally the tree harvest is above allowable cut, and some tree species are being overcut, in Canada as a whole annual harvest is still well below allowable cut. It has been predicted that by the year 2000 harvest will about equal allowable cut.

VI In the past considerable damage has been caused in Canadian forests by imported insects and diseases. Current legislation preventing import and export of pathogens is enforced by the federal government in cooperation with international organizations.

VII Most forest reservation is within the National and Provincial Park systems, and recently reservation for scientific purposes has been in cooperation with the International Biological Program Terrestrial Conservation Sub-Committee (IBP/CT). The primary purpose of most forested parks is to provide recreation. The policy of the National Parks is to preserve the forest for recreation with the minimum of disturbance by man, and no commercial logging is permitted. Provincial parks include many classes of forested parks based on objective use; some of these parks permit multipurpose land use including commercial logging.

VIII There are 24 National Parks covering 76,211 sq. kilometers (29,425 sq. miles) and 1814 Provincial Parks covering 249,000 sq. kilometers (96,000 sq. miles). Many parks are forested and the largest occupies 76,211 sq. kilometers (29,425 sq. miles). The parks include many forest types, but there is no systematic coverage of all the types of forest particularly those of particular scientific interest such as evolving tree populations.

IX Although a great deal is known about the effects of forest management practices on tree growth and succession, little is known about the long term effects of such practices upon the soil, flora, wildlife and microclimate.

X Although many forested natural and wilderness areas have been reserved, there is no clear concept as to how these areas should be managed to maintain their natural character when natural destructive forces are controlled.

XI The forest wildlife is generally in balance with its habitat, but where the habitat has been greatly modified some species are endangered or even extinct. Few exotic animals compete with indigenous fauna, and such introductions are not encouraged.

XII It is suggested that there is a need for:

I A national forest conservation policy, and

II Application of a system of reserved forest sites to cover immediate, urgent needs.

III Re-examination of land use legislation as it relates to forest conservation.

IV Considering ways of integrating programs concerned with conservation of different components of the forest biome and associated research, so that an overall forest conservation philosophy can be developed.

V Development of further forest conservation programs in cooperation with the United States, particularly concerning tree species and forest types common to both countries.

VI Strengthening regulations controlling movement of tree material at an international level.

VII Increasing education at all levels on the principles of forest conservation.

VIII Research on identification of forests of particular scientific interest, effects of forest practices, population dynamics, management of natural and wilderness areas, relationship between the forest and the public, and quantification of the value of the forest as a recreation facility.

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FIGURE 1

The distribution of the forest regions of Canada based on Rowe's classification (27)


1957
FOREST
CLASSIFICATION
OF
CANADA
SCALE IN MILES
100 50 0 100 200 300 400
LEGEND
FOREST REGIONS
PRINCIPAL TREE SPECIES
Boreal
Predominantly Forest .... Spruce, balsam fir, aspen, white birch, jack pine
Forest and Grassland .... Aspen
Forest and Barren .... Spruce
Subalpine .... Engelmann spruce, lodgepole pine, alpine fir
Montane .... Lodgepole pine, aspen, spruce, Douglas fir
Coast .... Douglas fir, hemlock, Sitka spruce
Columbia .... White pine, larch, Douglas fir, spruce
Deciduous .... Maple, beech, tulip - tree, walnut etc.
Great Lakes - St. Lawrence .... Maple, beech, white pine, yellow birch, hemlock
Acadian .... Spruce, balsam fir, birch, maple, beech, pine
Grassland
Tundra

CONSERVATION OF GRASSLANDS

CONTENTS

CONSERVATION OF GRASSLANDS

1. INTRODUCTION

The purpose of this paper is to describe Canada's natural grasslands, their value to man, actions being taken to preserve them, the adequacy of these measures and future actions needed. The paper does not cover the man-made grass pastures in general.

2. HABITAT

The prairie grasslands include the southern portions of the provinces of Manitoba, Saskatchewan and Alberta. As grasslands they were inhabited by mammals and birds characteristic of grasslands, including bison, elk, prong-horn (antelope); small mammals, including a number of ground squirrels, and prairie dog species, birds including a variety of plovers and grouse, and perhaps most importantly in the wet portions, waterfowl.

The major region of natural grassland in Canada is located in the dry subhumid brown and dark brown soil zones and parts of the black soil zone of southern Manitoba, Saskatchewan and Alberta. Smaller areas of grassland are found in the valleys of south-central British Columbia and in the Peace River region of west-central Alberta. Within the brown and dark brown soil regions the landscape is characteristically treeless, while in the black soil region (adjacent to forest) there is an intermingling of forest and grassland. In the northern Great Plains grassland this intermingling of forest and trees makes up the "aspen grove region", in which the forest component (mostly *Populus tremuloides*) is confined to the sites of more abundant moisture (but not depressional) and the natural grassland to the sites of average to lower moisture availability.

The indications are that, following the melting of glaciers, the forest component of these grassland regions was more conspicuous until the xerothermal period, and that since then forest has survived in patches only in locations of favorable soil moisture content (e.g. margins of depressions, north-facing slopes, and areas of dune sand). The height growth of these was kept at a minimum by repeated occurrence of extensive fires over the region, prior to settlement by Europeans, which began to have a significant effect in the eastern parts of the grassland late in the 19th century. Since then, protection from fire has permitted these surviving patches of trees to attain considerable height stature. In parts of the black soil zone they have been able to spread horizontally by asexual means, but elsewhere their extension has been limited to the most favoured locations. There is no evidence that these patches of forest are extending into the open grassland region, since they are unable to migrate from one favoured habitat to another because of the difficulty (or impossibility) of sexual reproduction under grassland climate.

The grassland regions of western Canada can be conveniently subdivided into true prairie, mixed prairie, fescue prairie and palouse prairie. The true prairie is confined to the central lowland of southern Manitoba, being a northern extension of the grassland (dominated by spear grass (*Stipa*) and dropseed (*Andropogon*)) that occupies the corn belt of the United States. The open grasslands of Saskatchewan and Alberta are comprised of mixed prairie communities related to the grasslands extending southward through the Great Plains to northern Texas. In these grasslands the most important dominants are species of spear grass (*Stipa*) and wheat grass (*Agropyron*), with which are associated a number of other grasses and sedges. In the driest, warmest region blue gramma grass (*Bouteloua gracilis*) becomes an important codominant. Within the black soil region of Saskatchewan and Alberta rough fescue (*Festuca Scabrella*) is dominant to form the fescue prairie. In the valley grasslands of British Columbia at the lower levels bluebunch wheat grass (*Agropyron spicatum*) is dominant and gives way to elements of the mixed prairie at intermediate levels and of the fescue prairie adjacent to the Douglas fir (*Pseudostuga douglasii*) forest. The grasslands of the Peace River region have similarities to those of the most humid parts of the northern Great Plains. Throughout these grasslands grasses and sedges characteristically comprise 90 percent or more of the aboveground vegetative growth. The most abundant non-graminoid is pasture sage (*Artemesia frigida*). Conspicuous shrubs are not distributed through the grasslands, except in special circumstances, such as the sage brush (*Artemisia tridentata*) associated with the bluebunch wheat grass in British Columbia, the patches of western snowberry (*Symphoricarpos*) that occur in the mixed prairie, and shrubby cinquefoil (*Potentilla fruiticosa*) of parts of the fescue prairie (3).

Azonal types occur within the grassland region due to the occurrence of sandy deposits, salinity, depressional conditions, and elevation.

A close examination of the landscape shows that the land is generally rolling rather than flat and that during a wet year, in addition to the larger lakes which show on many maps, there are millions of small bodies of water in the small depressions. In a really wet year the grassland portion of Saskatchewan alone contains more than 4 million such bodies of water.

Water bodies tend to be very rich in flora and fauna, and as such provide excellent feeding sites for young waterfowl. The rims of aquatic vegetation provide shelter for the nests of many species of waterfowl and as a result over 50 percent of the North American waterfowl population breed in that area in a normal year.

3. VALUE OF GRASSLANDS

The prairie grasslands of Canada and of the adjacent northern United States are considered the "big duck factory" of North American waterfowl. Those waterfowl are a source of enjoyment and recreation to more than 2 million waterfowl hunters and perhaps 10 times that many people who are interested in observing, photographing, studying and enjoying the presence of waterfowl.

The major economic returns from the vegetation and animal resources of this region are expressed in terms of output of domestic livestock and livestock products, as well as that of field crops. The major field crop of the region is wheat and the major livestock crop is cattle. Approximately 70 percent of the grazing capacity is provided by natural vegetation, with the remaining produced by seeded pastures of various types.

The major scientific value of stands of natural grassland is related to its use as a reference point in studies of structure and function of ecosystems against which the impact of man's activities may be measured. These activities primarily include increased pressure on these resources due to man's increasing demands for food whereby grassland ecosystems are being used for crop and animal production. As technology increases, it should be possible to develop a management plan for use of resources that will result in sustained production. However, it seems axiomatic that the model will depend on the natural functions of the ecosystem as a basis for evaluating the degree of deviation which can be tolerated in the managed systems.

Over much of the northern Great Plains and central lowland the glaciated moranic nature of the landscape results in minor amounts of runoff. The water is trapped in small depressions. There is local evidence that water erosion can take place within these small basins, particularly if steep slopes are tilled. The major concern in management of grasslands in watersheds is in the foothills of the Rocky Mountains and in the valley grasslands of British Columbia. In both of these areas tillage needs to be limited to the relatively level landscape and grazing should not exceed the limits that result in erosion of surface soil.

4. EFFECTS OF MAN

Originally the prairie sloughs and potholes and the surroundings were used by wild mammals. Now much of the area has had the grassland cover replaced by cereal grain crops and the land is heavily managed for cereal production. Cereal production is compatible with waterfowl production up to a point. Unfortunately, however, the small water areas located in the large grain fields are a nuisance to the farmers. For that reason there is a tendency to drain the sloughs or fill them so that the farm machinery does not have to detour around them during planting and harvesting. In that way many thousands of water areas have disappeared and with them the production of waterfowl and the rim of aquatic vegetation associated with the water body. Some of the area, particularly in the western part, is used in a more traditional manner. The grazing of bison on native prairie grasses has been replaced by the grazing of domestic cattle on either native grasses or replacements more suited to pasture use. Stock grazing has a low impact on waterfowl production except that trampling of vegetation surrounding water areas may destroy nesting cover. The water areas themselves are usually maintained as a source of water for the grazing animals and are available for use by ducks also.

Tillage completely destroys the natural cover of higher plants and greatly modifies the consumer and microbiological components of the system. Modern cropping practices are designed to accelerate the rate of supply of moisture and nutrients to crop plants. One means of achieving this is to cultivate as black fallow every third year. This permits storage of moisture from precipitation and accelerates the rate of liberation of nutrients, particularly nitrates, into the soil subsystem. By this practice not only is the recently produced organic matter degraded rapidly, but the reserve of organic matter that has been developed under centuries of natural grassland cover is rapidly broken down. Characteristically, after 25 years of tillage, the organic matter content is 25 percent lower than in natural grassland. The half-life of organic matter in prairie soils is probably of the order of 1,000 years, with only a very small proportion of the organic content turning over in a very few years. It seems reasonable to doubt that the organic remains from annual crops will have the same resistance to degradation. Consequently, there may be a gradual deterioriation of the soil resource under tillage to the point where a relatively large proportion of the annually produced organic materials turn over rapidly and the organic content of the soil is very much lower than at present.

Of concern to the biologist is the fact that the agriculturalist is convinced that the effect of declining organic matter contents of soils can be overcome by increasing the rates of application of commercial fertilizers. Such a philosophy may seem reasonable in respect to the need for supplying the nutrient requirements of crop plants, but it does not provide for any other functions that the organic component of the soil may have in respect to sustaining the system. Nor does it account for the loss of nonrenewable components of fertilizers.

The long-term effect of use of insecticides and herbicides on crop land has not been sufficiently evaluated to forecast the extent to which these chemicals may be incorporated in a sustained cropping system. Consideration needs to be given to the possibility of gradual accumulation of some non-degradable materials that may be applied to croplands.

The dangers imposed on land resources by the use of tillage implements have already been experienced in drought periods. Improvements in tillage operations have decreased the possibilities of widespread soil erosion by wind in the future, but it is of note that the practices followed in this respect in Canada are not as intensive as those in the United States immediately adjacent to Canada. For example, strip farming is almost uniformly followed in northern Montana and North Dakota, while it has largely been abandoned in Canada. The major means of protection of the soil against wind erosion in the Canadian grassland zone is the maintenance of a straw mulch on the surface. Even this is not uniformly maintained by different operators, with the result that avoidable losses from the surface soil are still being experienced.

Dry land farming in grassland regions of the world is a relatively new occupation for man. On all continents the cultivation of dry subhumid natural grassland began only in the 19th century. Since these regions are

now very important sources of man's food, it seems essential that they be conserved and maintained in a productive condition. It would seem improbable that our present management systems, which have been arbitrarily planned on an economic basis, will prove to be sustainable on an ecological basis. We must think in terms of conserving the resource in a condition that will permit its use in perpetuity.

Experiments designed to measure the long-term effect of grazing have usually shown that, within the arbitrary limits that have been chosen in respect to intensity of use, the heavier the grazing intensity the greater is the rate of animal production. Fortunately, these studies have not shown a similar increasing economic advantage with increased rates of grazing. Unfortunately they have usually not been extended long enough to measure true long-term effects on the other ecosystem components that might have resulted from extended exposure to even the moderate or light rate of use.

Of concern in natural grasslands that are used for grazing, particularly those that are untillable, is the maintenance of a cover of natural grass. Overgrazing results in disappearance of the taller-growing species and replacement by shorter-growing ones. This is followed by a reduction in the proportion of the grass cover that is comprised of palatable species and an eventual replacement of grassland by a cover of weedy, unpalatable plants, usually not grasses. The palatable species are known as "decreasers" and the unpalatable ones as "increasers", due to their response to overgrazing. Eventually the community is invaded by exotic species, also of unpalatable nature. These stages of degradation have been observed repeatedly with overgrazing of the Canadian grassland.

At this time the first functional study of a total grassland ecosystem in Canada (being conducted at Matador, Saskatchewan) is revealing that plant production on grasslands is much greater than had previously been suggested and that the proportion of the shoot production that is being consumed under grazing is much less than the 55 percent that is currently recommended. Much more detailed consideration needs to be given to management plans that will permit more efficient utilization of grass production on native sites. However, the present extensive range type of management has been effective in maintaining large areas of grassland in a stage of succession which seems reasonable in relation to the climax. One of the beneficial effects on natural grasslands by man is protection from fire. Naturally-induced fires still occur, as well as man-induced ones, but there are much less extensive than in pre-settlement days because of the occurrence of artificial barriers imposed by tillage operations, human settlements, and roadways.

There are many other effects of grazing beyond that of removal of the plant cover. These include the direct effect of trampling on soil compaction which does not seem to be of consequence under dry conditions but may have some temporary influence in moist situations. Frost action in winter seems to be of importance in avoiding permanent effects through soil compaction. Livestock trails and heavily tramped regions around watering places may be important centres for initiation of erosion. Grazing indirectly affects other biotic components of the system in addition to the grazed plants. For example, certain herbivores (invertebrates, birds, etc.) are attracted to heavily grazed areas and thus increase the pressure on the vegetation.

5. CONSERVATION AND PRESERVATION

Until recently no need was recognized for the protection of grassland vegetation in the national parks system in Canada. The philosophy was that the grassland cover is replaced annually (for the most part), while a forest cover must be protected permanently in order to be maintained. The grassland system contains many organisms, in addition to higher plants, that may suffer due to lack of management on a conservation basis. Also the susceptibility of the natural grassland to cultivation and overgrazing by domesticated animals produces a system that is as susceptible as the forest system to destruction by man. Discussion of establishment of a national park in the grassland region is appropriate. Small areas of grassland occur within some existing parks (e.g. the Cyprus Hills Provincial Parks, the Elk Island National Park, and the Badlands Provincial Park) but these are only incidentally set aside and are not being managed to preserve their natural grasslands.

Attempts have been made to set aside small areas of grassland as natural areas for future research. Those efforts have been characterized by difficulty (or impossibility) in arranging for the preservation of such areas in perpetuity. For example, five such areas were set aside in Saskatchewan in 1941 by arrangements between units of the provincial, federal and university organizations but, despite vigorous action over a number of years, no legislation exists to protect these areas from destruction. It is relatively easy to make a current arrangement for the protection of grassland for research purposes, but a solution has not yet been devised as to how to maintain the identity of such an area. A major problem exists in the management of such an area, which is costly even if no research is being undertaken. The universities have been interested in maintaining field stations for teaching and research purposes, but these, too, are protected against future damage only insofar as the ownership or leasing arrangements permit.

The Canadian Committee on International Biological Programs has taken account of the need for preservation of such areas in its CT program. Large numbers of sites have now been selected throughout the grassland region, but discussions with provincial governments have not yet resulted in any of these being set aside on a reasonably permanent basis. At the Field Station of the Matador Project of CCIBP (the Canadian Grassland Project under IBP) the natural grassland is held on a twenty-one year lease from the provincial government with no assurance of continued preservation as a reference site, despite the fact that in no similar area of the grassland in Canada has such intensive ecological research been conducted previously.

6. FUTURE ACTION NEEDED

The implications of the above discussion for future action include:

1. There is a need for examination of cropping systems on an ecological basis, as distinct from an economic basis, in an effort to determine the extent to which man may be able to manage these systems in a manner that will permit their use in perpetuity for food production.

The indication is that a functional approach on a total ecosystem basis is essential to replace the piecemeal type of experimental approach that has resulted in the present management systems.

2. There is need for further consideration of range management practices to determine if ways can be found to maintain the grassland ecosystem in as good condition as is presently possible under extensive use, but by more efficient use of shoot production.

3. There is need to intensify among farmers their awareness of the hazards of wind erosion and to encourage a more widespread use of stubble mulch and strip crop procedures.

4. There is a need to arrange international cooperation in studies of animal and plant producing systems. This is important from the point of view of increasing efficiency of research by combining the results of studies in various parts of the world in reaching more valid analyses of management procedures. There is also the possibility that sustained production in some systems may be achieved only on an international basis, if the economic considerations are such that they may interfere with international trade.

5. There is a need for legislation to provide for the setting aside in perpetuity of examples of representative ecosystems. This must be such that it will assure that the systems selected will be maintained.

6. There is a need for financial support for the management of representative ecosystems that are set aside for current and/or future research.

7. SYNOPSIS

1. The major grassland areas of Canada occur in the southern portions of the Provinces of Manitoba, Saskatchewan and Alberta and in the interior of British Columbia. The biggest single unit is that centered on southern Saskatchewan and extending into eastern Alberta and western Manitoba.

2. The grassland fauna originally included bison, elk, prong horn (antelope), a number of small mammals and in the wet areas waterfowl and shore birds.

3. Arable agriculture has replaced the native grasslands on an area approaching 100,000,000 acres.

4. The ungulate wildlife has been largely replaced by domestic livestock.

5. The preservation of grasslands is incidental to other purposes in a number of federal and provincial areas.

6. The continuity of preservation is nowhere guaranteed in the long-term.

7. It would be desirable to maintain representative samples of grassland under long-term arrangements to permit study and comparison with modified areas.

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THE MIGRATION OF CANADIAN MAMMALS & BIRDS

CONTENTS

THE MIGRATION OF CANADIAN MAMMALS & BIRDS

1. MIGRATORY MAMMALS

Historically, the post Wisconsin megafauna had a broad range of systems (forest, grassland, parkland, taiga and tundra) to utilize. With an increasing adaptation to changing environmental conditions some populations vanished whereas others increased in number in the North American continent. Migration thus occurred in the large herds of North American bison which utilized different areas as winter and summer pastures and in which significant migrations numbering perhaps millions of animals occurred. There has never been in Canada a true forest migratory type, indicating that the forest ecosystem provides the necessary food and shelter without the need to migrate. In some areas of Canada the forest species, particularly the woodland caribou, show some propensity to change summer and winter pasturages, but this is generally not considered migration in the true sense.

As the migratory bison has now been eliminated from the scene the only remaining large forms which are still truly migratory are the barren-ground caribou and to a certain extent the polar bear. One group or population of caribou called the Porcupine Herd migrates into Alaska crossing the International Boundary in northern Yukon Territory. The barren-ground caribou of the Northwest Territories of which there are four major herds, traditionally use the tundra in the spring and summer principally for calving and the forest biotope (taiga) in the winter because of the availability of food and shelter.

The migratory caribou has been investigated at great length and their pathways documented (1). Administratively, the herds are managed on the basis of federal-provincial agreements and by each provincial or territorial game agency which holds the management responsibility.

The polar bear which also crosses provincial, territorial and international boundaries is also administered by federal-provincial agreements internally and may eventually be managed by an international agreement of participating nations on the sharing of research data and information on movements and harvests.

2. MIGRATORY BIRDS

The principal legal instrument for the management of migratory birds in Canada at the Federal level is the Migratory Birds Convention 1916, the Migratory Birds Convention Act 1917, and the Regulations passed thereunder. In addition to federal legislation each province and territory has a complimentary legal basis for managing the resource, usually embodied in a Fish and Wildlife Act.

Regulations passed under these Acts are normally amended annually and are used to set bag limits, possession limits, open and close

seasons and regulate the methods which may be employed while hunting. The effectiveness of regulations depends on both public acceptance and the presence of trained enforcement personnel. In Canada, enforcement at federal level is carried out primarily by the Royal Canadian Mounted Police aided immeasurably by the fact that all provincial enforcement officers hold ex officio appointments under the Migratory Birds Convention Act.

Legislation and enforcement of that legislation is not a sufficient basis for the management of a natural, renewable resource. It is necessary to set goals and objectives relating to the resource and the use to be made of it by humans. Briefly stated the present goals are as follows:

I To maintain a total population of waterfowl at levels not less than those which existed during the period 1956-62; and

II To manage migratory birds for the benefit and enjoyment of people, meeting recreational, aesthetic, and scientific needs for this resource as equitably as location of habitat and requirements for preservation of this resource permit.

These terms are extremely broad but they do provide some recognizable guidelines. In order to establish these guidelines and measure how effectively the goals are being met a tremendous need for an accurate data base has developed. It is important to know among other things the number of breeding birds by species, their distribution, reproductive success, size of the population which will be available for hunting in autumn, requirements for breeding, resting and wintering habitat, and the general distribution of birds in space and time. In short, the population ecology of the species.

These data are required in order to establish how many birds may be safely harvested without harming the breeding populations as well as to provide a basis for estimating the amount of habitat required to maintain those populations. The management of wildlife requires a great deal of knowledge of what might be termed the human side of the equation. Because man is the primary user of game species it is essential to know how many hunters exist, how successful they are, what species they shoot and how effective regulations are in manipulating both the numbers of hunters and their kill. These data are required in order to assess the demand upon the resource and to a degree, distribute the harvest on some equitable basis.

Because Migratory Birds are a mobile natural resource recognizing no political boundary and because of the Migratory Birds Convention (1916) with the United States, close formal and informal liaison and co-operation is essential. Both countries contribute to programs designed to measure population sizes, distribution and mortality. Canadian and United States representatives attend policy meetings on a reciprocal basis. The International Migratory Bird Committee consisting of senior officials of both governments meets at regular intervals to discuss matters of mutual

concern. Scientists of both countries work very closely with one another and frequently publish joint papers.

In summary, the management of wildlife requires legislation, enforcement, public acceptance of the need for management, detailed knowledge of the population ecology of the various species involved and finally a demographic study of the hunting universe.

In the long term there is no problem in conservation of migratory species within the boundaries of Canada. There are few, if any, problems regarding the international management of the same species. Canada is convinced that it is dealing internally (with Provinces and Territories) and with other nations that are committed in a similar fashion to the conservation and preservation of migratory species.

THE CONSERVATION OF EVOLUTIONARY CENTRES IN CANADA

CONTENTS

THE CONSERVATION OF EVOLUTIONARY CENTRES IN CANADA

1. INTRODUCTION

The concept of biotic evolutionary centres is concerned essentially with centres of origin of species. This subject was considered in detail by Cain (4) who discussed the characteristics of centres of origin and how they may be recognized. The importance of centres of gene diversity, one kind of centre of origin, was first developed by Vavilov (1949-1950) who recognized them as regions of diversity in cultivated plants (24). Zhukovsky (in Leppik, 11) distinguished between primary and secondary gene centres and Leppik (11) showed the importance of these centres as sources of genes for disease resistance in cultivated plants. The importance of evolutionary centres of cultivated plants and domestic animals has long been recognized by plant and animal breeders and in recent years the importance of gene centres to tree geneticists has been stressed (13). However, the significance of evolutionary centres of non-economic species has not been generally recognized nor has their protection received general endorsement.

The purpose of this paper is to show that evolutionary centres occur in Canada and that, while they are not primary centres in a world sense, they are of importance to the study of evolutionary biology and biogeography, are gene reservoirs for plant and animal breeding, and contribute to the continuing development of the world's biotic diversity.

Evolutionary centres can be defined as geographical areas in which the plant and animal populations are actually or potentially undergoing evolutionary change. While these centres have as their common denominator a propensity for change a number of types of centres can be recognized each with its own characteristics. Evolutionary centres may be localized areas in which a number of species are (i) geographically isolated from related populations and subjected to different selection pressures, or (ii) are exhibiting high gene mutation rates; or the centres may be regions in which (iii) related species are hybridizing and producing new genetic combinations, or (iv) where species reach the edges of their ranges and are subject to "extreme" environmental pressures. Whether or not these processes are innovative depends upon the particular case. However, defined in this way, there are recognizable evolutionary centres in Canada.

2. EVOLUTIONARY CENTRES

Evolutionary centres can sometimes be recognized by the occurrence of localized new or incipient species known as endemics. These endemics may be biological innovations and reflect a dynamic evolutionary situation or they may be relict populations with little evolutionary potential. Since it is difficult to distinguish between youthful and senescent endemic populations without extensive study the two types will not be discriminated between in this report. However, even senescent relict endemic populations are of historical evolutionary interest and their preservation is important.

Botanically endemic areas in Canada include the Northern Peninsula of Newfoundland, Anticosti Island, the Mingan Archipelago, and the Shickshock Mountains of the Gaspe Peninsula, Quebec, the sand dunes region of Lake Athabasca, Saskatchewan, alpine regions in the Rocky Mountains of Alberta and British Columbia, the central Yukon plateau, the Arctic Archipelago, N.W.T., and the Queen Charlotte Islands, B.C. (2, 5, 7, 14 and 15). Most of these endemic areas are probably refugia rather than active evolutionary centres but the plant populations on the south shore of Lake Athabasca seem to be in an active evolutionary state (2) and the central Yukon plateau contains plant populations which survived the Pleistocene glaciations in that area (16). These two regions are particularly important, the first because of its evolutionary dynamism and the second because it contains gene pools which have withstood the vicissitudes of the Pleistocene glaciations in a northern locality.

The Queen Charlotte Islands have lost, by extinction, one large species, the Queen Charlotte Islands caribou, *Rangifer tarandus dawsoni* (Seton). The small mammal population, which has been relatively untouched, is uniquely different on each island in the group at the sub-species level (6). In this respect most isolated island populations can be characterized by such isolated gene pools unless further sub-divided by internal geographic or other barriers: A review of the arctic mammals by Macpherson (10) indicates not only the diversity in distribution from areas south of the receding Laurentide glacier and northern refugia but also that there are still evolving forms which intergrade chiefly in that area between the tundra and taiga biomes called the tree-line. Even the tundra-specific and forest-specific forms are still undergoing "evolution" seeking a balance with the environment in a dynamic process of adaptation. Because of meagre available energy in tundra areas the megafauna survive and multiply at levels below their potential whereas smaller forms particularly those in a sub-nival environment are more localized and generally cyclical. Those latter species have constantly expanding and contracting gene pools.

The possibility that there are plant evolutionary centres in Canada which are characterized by a high gene mutation rate has been suggested by the report of unusual variation in blueberry (*Vaccinium*) and fireweed (*Epilobium*) in the Uranium City area on the north shore of Lake Athabasca, Saskatchewan (20 and 21). The possibility that radioactivity levels in this region have resulted in an increased mutation rate has not yet been carefully studied and deserves further consideration. There is also a possibility that the rapid evolution which is apparently occurring in the sand dunes on the south shore of Lake Athabasca is also contributed to by high radioactivity levels.

Evolutionary centres may be areas of population mixing and therefore high morphological variation. Plant migration rates since the retreat of Pleistocene ice are such that many eastern species populations have reached the Mackenzie Valley and southern Yukon whereas those species which survived in central Alaska and Yukon have only extended their ranges eastward to the Mackenzie Valley and southern Yukon. The northwestern populations may have been slowed down by the Mackenzie Mountains which act as

a barrier or possibly by their reduced genetic, and therefore migratory, potential resulting from their relatively small population size. In any case, the southwestern Mackenzie, southern Yukon and northern British Columbia is an area in which eastern and western populations of the many plant species have in recent time rejoined their ranges and it is an area of high population variation. Several tree species including larch (*Larix laricina*) (17) and the willow (*Salix glauca*) (1) show this type of pattern. This region, because of the interaction between eastern and western gene pools, has a high evolutionary potential.

Population mixing undoubtedly occurs in the barren-ground caribou population of mainland Canada. As postulated by Kelsall (9) there are numerous population shifts particularly in the taiga but whether these shifts are by discrete herd units with no interchange of genes with other distinct herd units from a group which migrates and calves in another locality is not yet completely known. If in fact such an interchange does take place the northern edge of the taiga would thus become a significant evolutionary centre.

Hybridization between closely related species produces zones of evolutionary activity. The *Picea glauca* complex in western Canada consists of four closely related species which hybridize where their ranges come into contact (23). The hybrids become established in intermediate habitats and provide new genetic combinations for natural selection to act upon.

Hybridization between closely related species is an ongoing phenomenon particularly in the more mobile species. The areas of interaction (at boundary zones) provide a great deal of genetic variability. This is abundantly clear with such species as the wolf (*Canis lupus*) which has varying areas for population centres throughout North America and differentiated populations subject to rapid gene flow (8) particularly where mobility over long distances such as in the tundra is the usual pattern rather than the more fixed territory of boreal sub-species. Hybridization of barren-ground caribou (*Rangifer tarandus groenlandicus*) with the Peary caribou (*Rangifer tarandus pearyi*) occurred historically in the Arctic Islands (10) and is undoubtedly still occurring. The same process is also occurring in the Yukon Territory where the white Dall sheep (*Ovis dalli dalli*) and the Sontes sheep (*Ovis dalli stonei*) intergrade. Finally, a natural phenomenon such as flooding in estuarine or delta areas is a disseminating factor and hybridization particularly in previously isolated gene pools occurs. This was a significant factor in the Peace-Athabasca delta, among other areas, for revitalizing muskrat populations.

A final type of evolutionary centre, not properly termed a centre at all but really a large zone, is the edges of the ranges of species. For example, there are a number of tree species which reach their northern limits in southern Ontario. These species are experiencing environmental stresses that are selecting individuals for genetic characteristics which permit them to survive under these "extreme" conditions. It is from zones such as this that individuals which will be capable of growing under more northerly conditions may be obtained. The same is true of species whose

edges of range extend into the drier prairie regions or into the sub-arctic or sub-alpine regions. The edges of species ranges are of particular interest to silviculturists and provide a possible basis for cooperation between American and Canadian biologists.

Because of mobility most mammals are constantly extending their ranges but the process is dynamic and contraction also occurs. Because extension of ranges may only be an artifact of reportability the significance of this phenomenon has not yet been assessed. Generally for those species that are not biome or area specific, the gene pool is plastic and selection an active process.

3. THE VALUE OF EVOLUTIONARY CENTRES TO MAN

The value of these evolutionary centres to man can be expressed in scientific, economic and educational terms. The scientific value of such areas is as materials for the study of evolutionary processes, the understanding of the effects of unusual or severe environmental stresses on populations and in unfolding the history of the Canadian biota. North American plant and animal populations, which were largely destroyed in Canada by the onslaught of Pleistocene glaciations, are still in the process of re-migration and adaptation and the species are dynamically coming into contact with new environmental stresses.

The economic importance of these evolutionary centres is as sources of genetic material for plant and animal breeding and species improvement and as active areas in which natural selection is acting on dynamic gene pools, thereby naturally producing new genotypes which may be of economic value to man.

Man has always had a curiosity concerning the origin of man himself and the biota around him. The study of evolutionary centres can provide him with insights into the manner in which species evolve, migrate, become senescent and finally extinct. The educational and aesthetic values of evolutionary centres are closely linked to and complementary with their scientific value.

4. EFFECTS OF MAN ON EVOLUTIONARY CENTRES

What are the effects of man on these evolutionary centres? In the first place man may actually be the creator of some evolutionary centres.

Hybrids between black spruce and red spruce in New Brunswick do not become established in habitats occupied by either parent but are successful in cut-over forests (12). In this case man is inadvertently furthering a natural genetic experient. However, at the same time man is a potential destroyer of evolutionary centres that are already established. For example, the Lake Athabasca sand dunes are under uranium exploration leases (18), and the survival of the endemic species in this area is threatened. The northern edge of the ranges of some tree species in southern Ontario are threatened by the expansion of man's activities in

this area. Scientists and amateur botanists also are responsible for the destruction of some species in evolutionary centres. For example, there is evidence that some of the endemic species on Mount Albert in the Schickshock Mountains, Quebec, have been eliminated by overzealous plant collectors.

In general, however, evolutionary centres in Canada seem to be little threatened by the actions of man at the present time. Some centres are already located in national or provincial parks, others are geographically remote and are not feeling the pressure of man's incursions. Major migrational pathways such as the Mackenzie Valley and the southern Yukon are so extensive that they do not now appear to be threatened by man, while other evolutionary centres such as those of hybridization may actually be encouraged by man's activities. However, this situation is subject to very rapid change and with the possible development of an oil and gas pipeline system in the Mackenzie Valley, the increase in mining operations in the central Yukon, the possibility of uranium mining on the south shore of Lake Athabasca, and the multiple use development of Banff National Park even these remote areas may come under excessive human pressure.

5. ACTION BEING TAKEN TO PRESERVE EVOLUTIONARY CENTRES

There is little direct action being taken at present to preserve evolutionary centres as such. Exceptions to this are the efforts by the National and Historical Parks Branch to save the Lake Athabasca sand dunes and the Long Range in Newfoundland, and their restrictions on the collecting of some rare or localized plant species in Banff National Park (15).

The IBP-CT (International Biological Program, Conservation of Terrestrial Biological Communities) is presently documenting natural areas (19) which they think should be protected as ecological reserves. Some of these areas are evolutionary centres. Once the documentation is completed the major step of implementing protective measures will begin. Just how successful the IBP-CT will be in preserving these areas remains to be seen.

6. FUTURE ACTION IN CONNECTION WITH EVOLUTIONARY CENTRES

In the Canadian context what is most urgently needed is an expansion of our biological exploration program. There are vast areas of Canada for which our knowledge and appreciation of the floristic and faunistic components is very superficial. The Mackenzie Valley has not been thoroughly explored from a biotic point of view. The mountains of central Yukon are largely unknown and only one-fourth of the sand dunes on the south shore of Lake Athabasca have been visited by biologists. What we are suggesting is that a biological survey of those regions, which may hold very important genetic reserves and which may be biotic evolutionary centres, is long overdue.

Secondly, biosystematic study of species in evolutionary centres must be undertaken. In many instances it is impossible to appreciate the true extent of within population genetic and morphological variation or to define centres of origin without experimental and biosystematic study. Unfortunately few such studies are being carried out in Canada at the present time. Taxonomic and biosystematic research, both in the Federal Government and in the universities has been grossly undersupported. As a result, few taxonomists are being trained in Canada and the lack of opportunities in the profession has led to the loss of a large number of scientists.

Thirdly, some form of national or international cooperation with reference to the disturbance of important evolutionary centres and species populations by scientists as well as industry or the general public should be undertaken. The "Guidelines for Biological Field Studies" (3) which have been initiated by a number of Systematic Institutes in the United States and are currently being endorsed by many others throughout the world could be used as a model for action.

Finally, it should be emphasized that evolutionary centres are not simply an aggregation of species which are undergoing evolutionary change but a complex ecosystem including biological and physical elements without which the species would be unable to survive. For example, if we are to be concerned with the preservation of the northern edges of the range of certain hardwood species in southern Ontario we must also be concerned with the preservation of the ecosystems in which they live. This means not simply saving tree species but also preserving the entire nature environment. It is essential that we do not separate the consideration of evolutionary centres from that of ecosystems.

7. SYNOPSIS

1. Evolutionary centres are geographical areas in which plant and animal populations are actually or potentially undergoing evolutionary change.

2. Evolutionary centres in Canada include endemic areas, areas of fusion between formerly isolated populations, areas of hybridization and the edges of species ranges.

3. Evolutionary centres are of scientific, economic and educational value to man.

4. Man's effect on evolutionary centres ranges from the beneficial such as in the case of certain hybrids to the detrimental. However, at the present time evolutionary centres in Canada are not severely threatened by man's activities.

5. Direct action to preserve evolutionary centres is limited. However, such centres are often included in other considerations and some are already protected in provincial or national parks.

6. Future action on evolutionary centres should include, (a) the development of a biological survey, (b) biosystematic study of species in evolutionary centres, and (c) national and international cooperation to prevent destruction of evolutionary centres.

7. The preservation of evolutionary centres is not simply the preservation of species which are actively evolving but is inextricably connected with the preservation of ecosystems of which the species are a part.

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CONSERVATION OF THE RESOURCE OF THE AQUATIC ENVIRONMENT

CONTENTS

CONSERVATION OF THE RESOURCE OF THE AQUATIC ENVIRONMENT

1. INTRODUCTION

Canada's early history was intimately linked with that of her valuable Atlantic coast marine fisheries. Although other resources now have greater monetary value, the aquatic resources of Canada are still important through both the commercial and expanding recreational fisheries. The purpose of this report is to briefly describe these resources, and Canada's endeavour to utilize them without detriment to productivity or environment.

Canada borders on three world oceans, the Atlantic, Arctic and Pacific, contains a major inland sea, Hudson Bay, has the longest national coastline in the world and contains or shares 25 percent of the world's surface supply of fresh water. The resource potential in these waters is large and, except for those within complete dominion, is shared through treaties, agreements and codes with other nations.

2. VALUE OF THE RESOURCE

The ecological, environmental, economic and social problems differ in each of the four areas chosen for discussion of the fisheries: Atlantic, Pacific, Arctic and inland. The Atlantic region has a broad continental shelf of nutrient-rich waters and a multi-species resource dominated by demersal fish and invertebrates. Its industry is over-capitalized, has a surplus labour force, and is divided into small operating units spread over an extensive geographical area. The Pacific coast has only a narrow shelf, except in the far North where halibut and other demersal species are important, and its main fishery is dependent upon pelagic and largely migratory species. Its industry is also overcapitalized but is concentrated in a few large well organized companies operating from two principal locations. Its labour force is small but technologically efficient. The Arctic has few fish that are of value beyond local or domestic use. Some fish are caught, processed and marketed through isolated, government-sponsored cooperatives. Both capital and labour are minimal. Marine mammals figure prominently in the arctic resources but are primarily for the domestic market. Canada's inland waters produce low natural yields of fish, which generally diminish from south to north. Regionally these inland fisheries vary, with the most efficient management and capitalization concentrated in the Great Lakes area. High prices for the desirable products of northern waters support the less efficient industry of the small lakes of remote areas. The importance of Canada's commercial fishery is shown in Table 1.

Canada's sports fishery now attracts approximately 3,000,000 people who spend an estimated $500,000,000 annually on ancillary goods and services. The multitude of lakes and thousands of miles of rivers and coastline augur well for further recreational development, and it is estimated that over $1 billion dollars will be spent annually on sport fishing by 1980.

Table 1. Importance of fisheries in the Canadian economy.

Year	World Catch $Q^{(1)}$	Canadian Catch $Q^{(1)}$	Canadian Catch as % of world catch	Value $^{(2)}$ of all commodity-producing industries in Canada	Market value $^{(2)}$ of all Canadian fisheries products	Market Value as % of total industries	Numbers of fishermen employed in primary industry
1954	27,600	1027	3.72	14,100.8	192.2	1.4	79,600
1959	36,700	1054	2.87	18,536.6	204.1	1.1	80,100
1964	52,700	1211	2.30	23,300.9	295.2	1.3	78,100
1967	60,700	1303	2.15	29,842.0	330.0	1.1	71,200
1968	64,000	1490	2.33	31,818.9	384.1	1.2	68,400

Source: Annual Statistical Review of Canadian Fisheries.

(1) - quantity in thousands of metric tons

(2) - value in millions of dollars

The marine and fresh waters are valuable for many of man's purposes such as producing electricity, manufacturing goods, processing materials, supplying agricultural and domestic needs and providing a base for recreation. Some of these uses may conflict with those of the biological resource and require priority decision.

Culturally, aquatic resources have been important to man. His first advent to sea was probably in pursuit of fish, and proximity to the supply and processing facilities led to the distribution of many settlements with dependence on a single industry. The 'outports' of Newfoundland, of which there were over 1000 not so long ago, and the shore communities of the Maritime provinces and Quebec are examples of this development.

3. EFFECTS OF MAN ON THE RESOURCE

Over- or under-exploitation of the resource and alternative priority use of the environment frequently defeats man's attempt to harvest the renewable aquatic resources for the maximum sustainable quantity, quality or value of yield.

Over-exploitation of many species is known and documented. Examples of overfishing include herring on the Pacific and Atlantic coasts, Atlantic haddock and marine mammals. The high ratio of stock to yield of the slower growing and late maturing species of polar and temperate waters is particularly vulnerable to overfishing of which modern highly automated fishing fleets are capable. Under-exploitation rather than over-exploitation has probably been responsible for a smaller catch of aquatic resources by Canada in the past. Increasing demands for protein have resulted in a more aggressive fishery and many species not previously utilized are now actively fished.

Conflicting environmental priority has led to the demise of a number of fisheries. Pollutants from domestic, industrial, manufacturing, shipping, forest, agricultural and engineering sources can cause severe damage to aquatic resources. Industrial and manufacturing establishments have used rivers, lakes and sea as effluent sinks. Trout and salmon have suffered in many rivers. Only recently Atlantic herring and other marine fishes were killed in large numbers by the toxic effluent, containing elemental phosphorus, from a plant in Placentia Bay, Newfoundland. Forest and agricultural pesticide sprays often reach water where their lethal and sublethal effects are perpetuated on aquatic organisms. The excess as it concentrates through stream run off continues to kill and to change the aquatic ecology. The effects on the survival of young Atlantic salmon of DDT sprayed over New Brunswick woodland to control the spruce budworm have been well documented. Discharged mercury forms methyl mercury, accumulates in animal life and becomes a lethal pollutant. Animal wastes in runoff waters may result in high coliform counts in shellfish. Large supertankers and cargo ships now transporting oil and other chemicals pose major threats to aquatic life. Recent follow-up studies of the discharge of 2.5 million gallons of Bunker C oil from the motor vessel "Arrow" off the east coast of Nova Scotia failed to show any immediate pronounced effect on the aquatic life except where actual contact between the animal and oil occurred, as with shore life and sea birds. Engineering developments such as road building, dam construction, dredging, mining, oil well drilling, logging, seismic studies may all have undesirable effects in nearby or contained water life. Silting of habitat areas is a common effect of many of these activities.

Changes in species composition through pollution, fishing or otherwise, may increase yield of some fisheries as is indicated in the smelt and perch fisheries of Lake Erie. For example, lamprey suppression in Lake Superior has allowed young lake trout to survive to mature adults. Starfish depredations on Atlantic coast oyster beds are checked by mopping and liming operations.

Barriers to fish movement can have variable consequences on total yield. Geographic features prevent the spread of species, and a number of apparently successful introductions have been made, for example Pacific salmon into Lake Michigan and into Newfoundland; and Japanese oysters have long been cultivated in British Columbia. Impoundments created by barriers may result in the abundant survival of some species, but in the loss of diadromous fish unless channels are left or ladders supplied for their passage.

Man is able to enhance the production of some species by supplying more of the needed elements that are in short supply. Lakes have been made accessible through the removal of obstacles in rivers and streams; specially prepared salmon spawning channels where environmental conditions can be controlled have been built in British Columbia and Newfoundland; refugia have been created; food, species, "luxury" species and species able to fill additional niches have been introduced.

Genetic composition of a species may be changed through selective fishing of the stock, transplanting to new locations, selective and hybrid breeding. Such changes may affect the resiliency of the species to respond to environmental fluctuations, alter migratory routes, and/or timing or the production potential.

Man has practised aquaculture for centuries but many aspects still need research and development in Canada. In the recent past, however, major developments in this field have occurred. For example in the central provinces rainbow trout are being reared to marketable size during a single year's open water period in shallow lakes that winterkill through oxygen depletion. Oyster culture, already technically efficient in Canada, is being advanced on both the Atlantic and Pacific coasts.

4. ACTION BEING TAKEN TO PRESERVE THE RESOURCE AND ITS ADEQUACY

Many of the deleterious effects of man on his aquatic resources are outgrowths of historical practice, insufficient knowledge, previous and ad hoc policy, multiple uses of water, social and economic conditions and national and international competition. Problems under national control are corrected as conditions warrant but many resources are shared with other nations and must be managed jointly. Canada now cooperates with many nations in obtaining scientific data and formulating management proposals. The rational development and conservation of fisheries of common concern is ensured through membership in nine international fisheries commissions and one international council. These are set out in the 1969-1970 annual report of the Department of Fisheries and Forestry, and a brief summary follows:

The International Council for the Exploration of the Sea, formed in 1902, encourages and coordinates studies of the marine environment with particular reference to its living resources. Canada became a member in 1967 and participates in cooperative oceanographic and biological investigations and in the annual scientific meetings.

The Fur Seal Treaty of 1911, drawn up between Canada, Japan and U.S.A., provides for the conservation of a single marine species. It became inoperative during the early 1940's and a new Convention on Conservation of North Pacific Fur Seals came into force in 1957.

Canada joined with the U.S.A. in 1923 to form the International Pacific Halibut Commission. The convention provides for development and maintenance of the maximum sustainable yield of halibut in the north Pacific Ocean and Bering Sea. The commission maintains a scientific staff to provide data on which regulations are based.

The International Pacific Salmon Fisheries Commission, under a convention between Canada and the United States for protection, preservation and extension of the sockeye salmon, dates back to 1930, and was amended to include pink salmon in 1956. The commission conducts studies of sockeye and pink salmon in the convention area, regulates the fisheries and apportions the catch equally between fishermen of the two nations.

Canada has been a member of the International Whaling Commission since its inception in 1946. The Commission recommends scientific studies, determines the current condition of whale stocks and adopts regulations on open seasons, total catch quotas, closed areas and protected species.

The International Convention for the Northwest Atlantic Fisheries in force since 1950, provides for the investigation, protection and conservation of the fisheries of the northwest Atlantic Ocean to maintain a maximum sustained catch.

In 1968 Canada became a member of the Inter-American Tropical Tuna Commission. It conducts scientific investigations to provide data required to maintain the populations of yellowfin and skipjack tuna and other species of fish taken by tuna fishing vessels in the eastern Pacific Ocean, at levels which permit maximum sustainable catches.

The International North Pacific Fisheries Commission was established in 1953, with responsibility for promoting and coordinating scientific studies to ensure that fisheries of joint interest in the north Pacific Ocean are maintained at the level of maximum sustainable productivity. The convention is unique in that it includes the "abstention principle" whereby a member nation agrees to abstain from fishing stocks which are being fully utilized by another member nation, are subject to extensive scientific study, and are regulated through legal measures for the purpose of maintaining or increasing the maximum sustained productivity.

The Convention on Great Lakes Fisheries between Canada and the United States, established in 1955, is responsible for formulating and coordinating research programs designed to determine measures needed to make best use of the fish stocks of common concern, recommending management measures and implementing a program to control the sea lamprey.

The International Commission for the Conservation of Atlantic Tunas first met in 1969. It studies tuna and tuna-like fishes in the Atlantic Ocean and adjacent seas, and makes recommendations concerning measures required to maintain their populations at levels which will permit the maximum sustainable catch for food and other purposes.

The general principles of conservation as they apply to high continued yield are followed by all nations. But goals differ between nations and within nations depending upon species, region, socio-economic factors, production costs, market demand and competing water uses.

Commercial fishery production in Canada at present is valued at $400,000,000 annually. Lacking a home market, two-thirds of this production is exported. As a consequence exploitation is principally on those species with ready demand and of high value. Conservation policy and philosophy has been to obtain the optimum economic return from these fisheries, but now emphasis should be on maximum sustained yield.

Canada, until recently, pursued a policy of unlimited licensed entry into her commercial fisheries. This created problems of surplus labour force and overcapitalization of industry which in turn resulted in higher fishing costs. It has been estimated that of the 70,000 Canadian fishermen, 35,000 could be released from the industry, 25,000 from the Atlantic region alone, without a significant decrease in the catch of fish. Through changes in regulations and the promotion of other industries in fishing areas to supply alternate employment, Canada hopes to achieve a reduction in the labour force and an efficient utilization of capital invested in the fishing industry.

Canada's territorial sea was extended to twelve miles from three miles by amendments to the Territorial Sea and Fishing Zones Act approved in June 1970. These amendments also provided for establishment of fisheries closing lines, which came into effect in February 1971, designating major areas on both its east and west coasts as exclusive Canadian fisheries zones. The effect is to assert Canadian jurisdiction over an additional 80,000 square miles of coastal waters, and to extend to these waters the effective range of Canada's anti-pollution programs.

Canada has embarked on a policy to reduce pollution and to improve the aquatic resource base in all national and shared coastal and freshwaters. Included in the program are serious efforts to apply sound management procedures to all phases of the Atlantic seal fishery, so that the species will not be endangered. Aquaculture is being advanced as rapidly as technology and market demand will allow.

5. FUTURE ACTION NEEDED

Pollution degrades the environment, disrupts the ecology and depresses the aquatic resources. Legislation to control and clean up pollution has already been enacted for home waters, the Northwest Passage and visiting ships. But pollutants respect no national boundaries and international solutions are mandatory for protection of world aquatic resources.

Continued scientific investigation of the aquatic resources is required and expected. Traditional studies of species problems such as stock definition, assessment, manipulation and prediction are required for many important fisheries and for further aquacultural development. Management of the whole ecosystem in areas of mixed species holds promise for obtaining maximum yields for expended effort. Research towards this end should be continued and pilot plant developments undertaken.

Changes in our national policy of fishery management have been initiated by the restriction of entry of men and gear into specific fisheries and recommendations have been made in the interests of fishing efficiency, economic yield, welfare of fishermen and rational development of the industry. These include: limitation of entry of man and capital; creation of larger production and marketing units; expenditure of greater amounts in hatchery and stocking programs with high benefit-cost ratios; promotion of aquaculture; resource licensing to provide an economic benefit to all the people of Canada, and programs to employ people displaced from the fishing industry.

Canada is advocating that each nation should have the primary responsibility for management of adjoining aquatic resources out to the continental slope. They should be responsible for conservation of resident stocks and should set the upper limits for their exploitation. Fishing rights would be determined through international agreement.

6. SYNOPSIS

1. Canada's aquatic resources support commercial fisheries with total products now valued at $400 million annually.

2. Recreational fishing annually attracts 3 million people who spend an estimated $500 million on ancillary goods and services.

3. Canada's home market can use only one-third of her fishery products and the fishery has concentrated on species having ready export market demand.

4. Ecological, economic and social problems differ in the Atlantic, Pacific, Arctic and inland regions. The Atlantic, with broad continental shelf and multi-species resource dominated by groundfish and invertebrates is overcapitalized, has surplus labour force and a fishery divided into many widespread operations. The Pacific has a narrow shelf except in the north, and the main fishery is based on migratory and pelagic species, but halibut and other groundfish are important northward; its industry, also overcapitalized, is concentrated in a few large companies, whose labour force is small but efficient. The Arctic has few fish valuable beyond local use, and capital and labour are minimal; arctic char are marketed successfully through cooperatives; marine mammals are important but mainly for domestic use. Canadian inland waters have low overall fish production, diminishing from south to north, with best management and capitalization in the Great Lakes.

5. Canada's multitude of lakes and thousands of miles of rivers and coastline hold promise of extensive recreational development, and doubling of annual spending on sport fishing to over $1 billion is estimated by 1980.

6. Effects of man on the resource include commercial over-exploitation of some species and under-utilization of many others, while conflicting environmental priorities, and resulting domestic and industrial pollution, and a wide variety of engineering developments, have had disastrous effects on the ecosystem and associated fisheries. Fortunately man can reverse the trend and improve the resource, for example by overcoming barriers to fish movement, species introductions, selective fishing to change genetic composition, and selective breeding. Aquaculture is being encouraged in Canada, and major developments have occurred recently, e.g. production of rainbow trout in central winterkill lakes, and oyster culture on Atlantic and Pacific coasts.

7. Fisheries conservation problems that are under national control are corrected as conditions warrant, but many aquatic resources shared with other nations need joint management. Canada cooperates with other nations in obtaining scientific data and formulating management proposals, through membership in nine international fisheries commissions and one international council.

8. Canada's fishery conservation and management policy is to derive optimum economic return from her aquatic resources. Recent action limits licensed entry into certain fisheries for more efficient harvesting. Also, Canada's territorial sea has been extended recently to twelve miles from three miles, and fisheries closing lines have been established designating major areas as exclusive Canadian fisheries zones on both east and west coasts.

9. The effective range of Canada's anti-pollution programs has been extended.

10. Recommendations for future action in aquatic resource conservation include measures to control pollution and enhance the quality of the environment, expansion of high priority scientific investigations, and further changes in fishery management policy.

a. While legislation to control and clean up pollution has been enacted for home waters, drastic measures must be taken internationally to protect the world's aquatic environment.

b. Continued scientific investigation must include traditional approaches to species problems such as stock definition, assessment, manipulation and prediction, and more active research to promote the development of successful aquaculture for many species of fish and invertebrates.

c. Management of whole ecosystems should be an aim, involving mixed rather than selected species, to give maximum sustained yield at minimum cost.

d. Canada is advocating that each nation have primary responsibility for management of adjoining aquatic resources out to the continental slope, with each nation being responsible for conservation of the stocks resident therein and for setting upper limits for their exploitation. Then fishing rights would be determined through international agreement.

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CONSERVATION OF RIVERS, LAKES AND GROUNDWATER IN CANADA

CONTENTS

CONSERVATION OF RIVERS, LAKES AND GROUNDWATER IN CANADA

1. INTRODUCTION

The history of Canada has been characterized by a close association between man and water. For most of the historical period, the main importance of Canada's water resources has been in their usefulness as a means of transport. The country was discovered from the sea; the first settlements depended on the sea for their survival. In Canada, partly for physical, partly for historical reasons, water was equally important in the early colonization of the interior and exploration of the Arctic. There is a place in northwestern Manitoba from which it is possible to travel by canoe to the Pacific, to the Atlantic, to the Gulf of Mexico or to the Arctic Ocean, in each case with no single portage requiring more than a day to accomplish.

The importance of Canada's waterways as a transport medium has continued up to the present day. The Great Lakes provided opportunities for travel and commerce, and these were linked to the sea by canals along the St. Lawrence long before the St. Lawrence Seaway modernized the system. The Welland and Sault canals are perhaps the busiest in the world; the bulk of traffic involves Canadian ports and the importance to the Canadian economy is proportionately much greater than to the United States. Many of Canada's major cities including Montreal, Toronto, Vancouver and Halifax are also major ports.

It is, however, true that the role of water as a transport medium in Canada has declined relatively, though it continues to increase in absolute terms. At the present time, the main use which is made of water in Canada is probably that of sewage and effluent removal and dilution. As that growth has continued, and as public expectations of water quality have risen, so there is a progressive need for primary, secondary, and tertiary treatment. This rising expectation comes mainly because of the increasing importance which is attached to the recreational and aesthetic uses of water and to the importance of the water in the ecosystem.

In the present century, water as a component of recreation has become as important a symbol of the Canadian way of life as its transport function was of earlier centuries. Even more than navigation, water-based recreation is ubiquitous, at least over the area where the vast majority of the population is to be found. The recreational use varies widely, including fishing, boating, swimming and cottaging and many other aspects which involve both use and non-use of water. Included in the latter is viewing for aesthetic purposes, a use which must be valued highly in certain conditions, for example, at Lake Louise. The importance of water as a recreation source is surely one of the distinguishing features of Canadian life: water sports are popular in many countries but they are rarely as much a major component of the national scene (or of individual priorities) as in Canada.

If this national importance, as part of a Canadian identity, is accepted, it becomes a significant feature in determining future water policy, since it implies that, for Canadians, water is something more than a commodity and more even than a resource which is capable, directly or indirectly, of normal methods of valuation. To the Canadian economy tourism already represents the major single source of foreign income, more important than sales of wheat or gas, yet it poses major problems of national policy, problems which are scarcely less significant than questions of export of the water. Whether the water is exported as a resource commodity, or whether tourists are imported to use the water in cities may perhaps be regarded as two sides of a single problem. Importing tourists may well bring many of the benefits that would be obtained from water export, but it does involve major pressures on recreational resources of water which are large but not abundant.

The concern for the maintenance of the ecosystem, especially so far as wildlife is concerned, is related to the demand for recreation to the extent that ducks, fish, moose and other animals are major components of Canada's recreational potential. It is obvious, however, that the growing concern is not limited to hunters or fishermen. Nor is it limited to those who are concerned with the indirect effect on human health of contaminated fish and other hazards. Not for the first time in Canadian history, wildlife conservation and the preservation of a desirable ecosystem are important for their own sake and, while some of the more extreme passions which they have aroused seem likely to abate in the future, the increased concern for environmental quality is likely to be a permanent feature of future Canadian public and private policy.

2 DEFINITION OF THE RESOURCE

2.1 THE NATURE OF WATER RESOURCES

The inland waters of Canada cover an area of 292,000 square miles, about 8 per cent of the total area of the country. Canada is bordered by three oceans and also has a coastline of 17,860 miles, one of the longest in the world. It has been estimated that the Canadian portion of the Great Lakes alone, contains one-tenth of the world's supply of fresh surface water and all Canadian lakes together may contain one-third.

Precipitation determines the supply of fresh water, and this amounts to an average of about 19.5 inches over all of Canada. Much of this precipitation is lost in evaporation and transpiration, but it also generates a flow in our rivers totalling 2.5 million cubic feet per second. The upper limit to which water resources in a region can be consumed or diverted is thus ultimately governed by the amount of precipitation which the region receives.

a. Rivers

Each year the rivers of the world pour about 8,400 cubic miles of water into the sea. This represents an average flow of nearly 40,000,000 cubic feet every second. The total flow in Canada's rivers amounts to about 3,500,000 cubic feet per second, which is a little less than 9 per cent of the world's total. The St. Lawrence, Canada's largest river,

discharges some 400,000 cubic feet per second. The importance of rivers is related, not to the actual quantity of water in the channel at a given moment, but to the flow of water. Since this flow is produced by precipitation, and since precipitation is neither continuous nor uniform, the flow of the river is continually fluctuating. No two rivers are exactly alike in their characteristics, but all of them, from the smallest brook to the mighty Amazon, form a vital link in the hydrologic cycle.

b. Lakes

Canada probably has more lake area than any other country in the world. In size, Canada's lakes range all the way from Lake Superior with a surface area of 31,800 square miles (11,100 square miles of which is in Canada, the remainder in the United States) through such lakes as Great Slave Lake (11,000 square miles) and Lake Winnipeg (9,500 square miles), down to the myriad tiny lakes, many of them unnamed, with areas less than a square mile. The importance of lakes lies in their ability to store water, allowing rivers to survive through periods of low precipitation.

c. Groundwater

Groundwater is water found in the interstices of permeable material lying below the earth's surface. It is commonly withdrawn from the more permeable deposits such as sands, gravels and sandstones by wells drilled to intercept these deposits. Springs provide naturally flowing groundwater supplies.

The advantages of groundwater over surface water supplies (relatively constant temperature, less variable supply, relative freedom from pollution) have led to its widespread usage as a water supply for many small towns and villages in Canada. Although the quantity of groundwater used is much smaller than that of surface water, many communities are completely dependent on groundwater for domestic purposes. In other areas, groundwater is used extensively for cooling and air conditioning.

Although in general the usage of groundwater has not yet reached its maximum, in some places over-development has occurred and other sources of water have had to be located.

Problems of pollution of groundwater (biologic, chemical and thermal) have been recognized in many parts of Canada and legislation controlling, for example, temperatures of recycled water and construction of septic tanks is in force in many provinces. Of particular concern is the subsurface disposal of industrial and other wastes, both by direct injection into permeable subsurface strata and by infiltration from such sources as disposal ponds, sanitary landfills, feed lots, and agricultural usage of fertilizers and pesticides. Most of these disposal methods are adopted consciously as alternatives to more conventional waste treatment and disposal methods. They are not uncommonly regarded as "solutions" to the waste disposal problem. In reality, however, they may be concealing the problem rather than solving it, thus rendering it more insidious and its eventual solution more intractable.

Biologic and chemical contamination of groundwater resources is a problem that Canada shares with many other countries; thermal pollution has special Canadian connotations that are shared only with other countries with extensive permafrost regions. The increase in engineering, mining exploration and industrial activities in the Canadian North tends to affect the permafrost zone and lead to local melting. Since this zone commonly serves as an impermeable barrier to the movement of groundwater to the surface, local melting can provide paths for leakage of water to the surface with a consequent reduction in the total groundwater resource and perhaps some undesirable effects at the surface as well. Even the very act of attempting to develop groundwater resources below the permafrost can lead to melting of permafrost around the well bore and perhaps to unwanted movement of groundwater toward the surface.

There is much Canadian interest at the present time in obtaining more of the basic data that will allow us to gain a clear picture of the precise threat that pollution poses to our groundwater supplies. In the meantime, those bodies empowered to regulate waste disposal methods in Canada should approach the subsurface waste disposal alternatives with some degree of caution, bearing clearly in mind that they are not necessarily solutions, only restatements of the basic problem. Approval to dispose of wastes into the subsurface should only be given in recognition of the fact that there is probably a tradeoff involved: the temporary shelving of a pollution problem against the possible future loss of a water resource or of subsurface space suitable for temporary storage of other fluids such as hydrocarbons.

A knowledge of the quantity and quality of the water resources of the nation, as well as their variability, is basic to the execution of a water management policy. Because of the dynamic nature of water resources, a single inventory measurement is meaningless.

Measurements of water levels and stream flows were initiated on a systematic basis in Canada since 1909 and, at the present time, data are collected at 2,500 locations from Yukon to Newfoundland. In 1968, a hydrometric network planning study was initiated by the Water Survey of Canada, intended in part to assess the adequacy of the existing network. Investigations to date have indicated that the present Natural Regime Network should be expanded considerably over the next five years or so (in some regions by as much as the existing number of stations in the regional network itself). Expansion of the network in the northern and uninhabited areas is a much more expensive operation than that in the southern regions of Canada. It is mainly in the former areas where data are quite inadequate. In the latter regions, the network is being expanded, because the increasing intensity of use requires a greater refinement of data. Such inventories must also provide for the collection of data on sediment transport and deposition by the water in rivers and lakes.

Problems in water use arise because precipitation and resulting river flow are not distributed uniformly throughout the year. For example, about 36% of the mean annual precipitation in Canada occurs as snow and most of this is held in storage for several months to melt in the spring of the year. At times, therefore, runoff is many times the average (sometimes

causing floods) and at other times it is only a fraction of the average. Fluctuations in flow can be reduced or even eliminated by the creation of artificial storage or by the improvement of natural storage. The advantages and possibilities of underground storage should not be overlooked. This general principle of holding high flows in a reservoir does raise some extensive ecological, environmental and social problems. A great many rivers in the populated areas of Canada are already controlled to some extent and it is likely that, as water use increases, storage sites will become recognized as increasingly important resources.

Not only does the non-uniform time distribution of water supply impose problems, as it does everywhere in the world, but also the non-uniform areal distribution creates a "plumbing system" not necessarily suited to man's activities. For example, the annual precipitation varies from as low as 12 inches on the Prairies to over 100 inches on the West Coast. Yet it is on the Prairies that the largest consumptive use is made of water through medium-scale irrigation works.

Even greater problems arise from Canada's topography - about 60% of the runoff is carried by the rivers flowing north. On the other hand, 90% of Canada's population is concentrated within 150 miles of the southern border of the country; in fact, more than half the population lives within the drainage basin of the St. Lawrence River and a major part of Canada's industry is located in this same region.

As demands for water approach or exceed the local supply, it is theoretically possible to move the people to where the water resources exist, or, more practically, to limit urban growth in areas of deficiency, while encouraging it elsewhere. The more usual alternative is to move the water to the people. In the past, such transfers were relatively small in scale, but in areas like California major transfers are already in existence and several schemes of a similar nature have been proposed either to solve Canadian problems or which involve Canadian water in the solution of such problems in the U.S.A. Such geographical redistribution of the water resource would have far-reaching implications for the ecosystems affected and it raises many other environmental and social problems. Even on a small scale, as in many examples in Canada at present, diversion of water out of, or into, river systems or even the creation of reservoirs changes the hydrologic regime of the river system. This can create substantial erosion or deposition problems as one can note in Northern Ontario. The suspended solids also effect the quality of the water considerably.

More generally, it is not sufficient to discuss water in terms of quantities only. Knowledge of the quality of the water in its natural state and the effects on man-made pollution are equally important for water management. It should be emphasized, then, that the inventory of Canada's water resources is inadequate so long as the present serious shortage of water quality data exists.

2.2 WATER QUANTITY

a. Hydrologic Cycle

The amount of water present at any specific time at any particular place in Canada is an extremely variable quantity because of the interaction

of many inconstant factors. For example, on the Red River at Emerson, Manitoba, the river flow varied from almost zero during several days in February 1937, to about 95,000 cubic feet per second in May 1950, and there is evidence that within the last 150 years there were floods which exceeded this recorded maximum.

The factors affecting stream flow, although they may be subject to direct measurement for any given instant of time, cannot be predicted beyond that instant with any degree of certainty. As a result of this uncertainty of prediction, it is necessary, in all planning for the conservation and development of water resources in Canada, to adopt a method that assumes that future variations will follow the same general pattern as past variations.

b. Regional Variation in Runoff

A synoptic picture of the variation in runoff across Canada can be given on the basis of the five geological regions of Canada: the Canadian Shield; the Appalachian area; the St. Lawrence lowlands; the Great Plains; and the Cordilleran area.

The Canadian Shield makes up about two-thirds of the area of Canada and its climate varies from temperate to subarctic. The average annual precipitation varies from about forty inches in the east to ten inches in the far northwest. Annual runoff ranges from around twenty-seven inches in the southern portions to less than six inches in the northern sections.

The Appalachian area, which comprises roughly the Maritime Provinces and eastern Quebec south of the St. Lawrence River, reaches altitudes as high as 3,500 feet. Precipitation is about fifty-five inches per annum on the Atlantic seaboard, diminishing to about forty inches in the western portion.

The St. Lawrence lowlands area borders, and is drained by, the St. Lawrence River. Here the precipitation varies from thirty to forty inches per annum. Precipitation in the Great Plains varies from around twenty inches per annum in the east to fifteen inches or less in the south and west. The pervious terrain and slight gradients of the rivers are unfavourable to runoff which, from the purely plains river basins, is generally less than one-half inch, or about 2 per cent of the precipitation.

In the Cordilleran area, the topographic and climatic conditions vary so greatly that it is difficult to generalize about the runoff. However, on the eastern slopes of the Rocky Mountains, melting snow from the higher altitudes produces runoff varying from about seven inches to twenty-seven inches. In the central belt of plateaux and mountains, runoff ranges from fourteen inches to upwards of forty inches. The western belt of the Cordilleran, including the coastal and insular mountain ranges, receives precipitation which exceeds one hundred inches per annum in the higher altitudes with the mean annual runoff ranging over fifty inches from fairly large watersheds, such as the Nass River basin, of about 6,900 square miles.

c. Measurement of Canada's Surface Water Resources

The history of the hydrometric survey in Canada began in 1894 when some stream measurement work was performed in connection with the irrigation surveys made by the Forestry Branch of the Department of the Interior. In 1908 the federal Parliament made its first specific appropriation "for gauging streams and determining the water supply in southern Alberta and Saskatchewan" and for this purpose the Hydrographic Survey was established in 1909 with headquarters at Calgary, Alberta.

At present, the hydrometric survey program today literally spans the nation with data collected on rivers and lakes from the Yukon Territory to Newfoundland. At present the program is carried on through six District Offices and thirteen sub-offices of the Branch. Data are collected at over 2,000 different locations and the results are published annually. These records vary from continuous observations of levels on principal rivers and lakes, reduced for publication to mean daily values of flow or elevation, to intermittent observations of level or miscellaneous measurements of flow on lakes and streams in isolated areas or where current requirements are for a minimum of information.

2.3 WATER QUALITY

a. Historical

Water quality network and surveillance programs have been conducted on Canada's surface waters with increasing intensity by federal and provincial governments for the past several decades. As part of its commitment to the International Hydrological Decade (IHD) programs in Canada and because of new and rapid advances in industrial technology and an ever-increasing demand for up-to-date information on water quality, the Department of the Environment has established during the past 5 years, comprehensive and long term water quality sampling programs on Canada's surface waters. These surveys are somewhat more detailed than the previous studies and are designed to produce more accurate data and information on water quality, required by water users and agencies engaged in pollution abatement programs.

b. Present

The Department of the Environment now operates about 900 water quality sampling stations in its nationwide water quality networks including some 340 sampling stations on the Great Lakes. The water quality data from this network are stored and processed in an automatic data processing system and are published by provinces or regions on an annual basis.

Other federal departments such as the Departments of Fisheries and Forestry and National Health and Welfare operate limited water quality networks in regional areas of Canada, such networks being designed to investigate local problems of special concern to these respective departments and to support research programs on specific projects.

During the past 10-15 years, Ontario, Quebec and Alberta have established water quality networks within their boundaries. The parameters measured in the Department of the Environment water quality networks are for

the most part, the major ions, pH, specific conductance, colour, turbidity, total alkalinity, iron, manganese, aluminum, zinc, copper, lead, trace elements including mercury, fluoride, phosphate, total nitrogen, nitrate, chemical oxygen demand (COD), biochemical oxygen demand (BOD), and total organic carbon (TOC).

TABLE 1. Water Quality by Physiographic Regions

Water quality by physiographic regions is summed up in the following:

Region	Rivers	Characteristics	Range (mg/l as $CaCO_3$)
Cordilleran	Fraser	Bicarbonate medium-hard	≤ 30
	Columbia	High colour very turbid	121-180
	Yukon	Highly corrosive	
	Skeena		≤ 60
	Stikine	Soft to medium-hard	61-120
Interior Plains	North and South Saskatchewan	Medium-hard bicarbonate	≥ 250
	Red-Nelson	Medium-hard alkaline earth bicarbonate very turbid	
	Churchill	Soft alkali earth bicarbonate	50
	Mackenzie	Very soft-very hard high turbidity	≤ 30 ≥ 180
	Mississippi-Milk	Hard and turbid alkali sulphate tributaries soft alkali earth bicarbonate at mouth	
Canadian Shield	Includes half of Canada and Labrador	Northern region Southern region	≤ 30 ≤ 120
Canadian Appalachian	Atlantic Provinces Eastern Quebec	Soft to medium hard	≤ 50
Arctic Islands		High alkaline high sulphate high colour	

3. VALUE OF THE RESOURCE TO MAN

Clearly distinguishable from instream uses such as recreation, which leave the water body in its natural location and condition, is the withdrawal of water by municipalities, industries and agriculture. A proportion of this water may be consumed: it may be evaporated or incorporated in a product and is not returned to the original source of the water. The remaining proportion may be returned to the source (or to some other watercourse), but changes in quality during its withdrawal would reduce the usefulness of the water as a habitat for fish, or for other uses. The simple view that consumption of water takes place only if water is withdrawn and not returned to the source must therefore be extended to include consumption of the quality of water. Consumptive uses, in the broader perspective, include all domestic and most industrial and agricultural uses.

The ecological support function of water does not, in principle, prohibit other instream uses. It is clear, however, that some forms of water resource development endanger the ecological balance in the basins concerned. Nature, undoubtedly, would achieve some new form of balance over time, but it may well be that this new condition is undesirable. How much man should allow himself to tamper with the ecological function of water is a question that requires comprehensive study, including the consideration of a far wider scale of factors and relationships than was considered appropriate only a decade ago.

Some values of various water uses are described below.

3.1 INDUSTRY

Industry has an enormous thirst for water. The largest quantity is used for cooling purposes, but considerable quantities are also used directly in many manufacturing processes; another important use is in plant sanitation. Frequently, figures are published to indicate how much water is used in various industries - figures like 10 gallons of water to refine a barrel of oil, 250 tons of water to produce a ton of sulphate wood pulp, 100 gallons of water to produce a gallon of alcohol. These figures are interesting as a general indication of the need for water, but they may be misleading. Far too often they reflect the fact that water is easily available, inexpensive, and therefore, often used inefficiently.

3.2 DOMESTIC AND MUNICIPAL SUPPLIES

Canada's earliest settlers, who had to carry or pump their household water supplies by hand, probably got by on five gallons or less per day for each person. Today each member of the average Canadian family uses from 20 to 70 gallons or more each day. Despite its variety of uses, water is probably the least expensive material used in the household. Compare the price of oil for heating (20 cents per gallon) or gasoline for the automobile (50 cents per gallon) with the cost of water piped to the house (less than a cent per gallon). At a cost of 34 cents per thousand gallons, water costs about 7 cents a ton, delivered. No other material costs so little.

3.3 FISHERIES

In 1867, the year that Canada became a nation, some 3.5 million pounds of fish were taken from fresh water sources, primarily the Great Lakes-St. Lawrence River System. Since 1867, fresh-water fisheries have continually expanded to the extent that, by 1964, the annual catch had increased to 105 million pounds, worth $18.3 million.

3.4 HYDRO-ELECTRIC POWER

Electrical energy has been called the master tool of mankind. In Canada, it is the economy's mainspring - the efficient servant of modern life. Canadian industrial development, since the turn of the century, has depended upon water power as its principal source of energy and despite the current emphasis on thermally-generated power, water power is still by far the leader. Of the 158,000 million kilowatt hours of electrical energy generated in Canada in 1966, 130,000 million kilowatt hours, or about 82 per cent, was generated in hydro-electric plants. Industry used over half of the total energy, commercial operations and street lighting about 15 per cent, and residential and farm, almost a quarter of the total.

3.5 TRANSPORTATION

Water provides the most economic means of transportation for the bulky raw materials of Canada's vital export trade - wheat, pulp and paper, lumber and minerals on their way to the world's markets. Annual freight traffic through Canadian canals and canalized rivers in the ten-year period from 1956 to 1965 increased from 40 million tons to 99 million tons, an increase of 150 per cent. The $470 million St. Lawrence Seaway, completed in 1959 is an indication of faith in the future of water-borne transportation. In 1965, nearly 25 million tons of cargo moved up the seaway, and over 35 million tons moved down.

3.6 AGRICULTURE

Most of Canada's agriculture depends on the direct natural supply of water to the land by snowmelt and rainfall. Of the approximately 62 million acres of land devoted to crops each year, an estimated 1,000,000 acres are irrigated. Practically all the irrigated land is in Alberta, British Columbia, and Saskatchewan.

3.7 RECREATION AND TOURISM

In 1941, little more than 50 per cent of Canada's population lived in towns and cities. In the 1960's, by contrast, town and city population made up about 70 per cent of the total. This trend toward living in large urban centres has been accompanied by a desire to return occasionally to non-urban surroundings as an escape from the pressures of modern city life. Much of the recreation sought by holidaying Canadians is water oriented.

Canada's GNP is over 65 billion dollars and tourism has a value of one and a quarter billion. A growing awareness of the recreational value of clean water to the country, to say nothing of the tourist dollars which water-oriented recreation can attract is increasing the number of programs devoted to the restoration of natural waterways which have become damaged or destroyed through indifference.

3.8 WASTE DISPOSAL

Usually last to be mentioned, but far from least in importance, is the vital service which water renders in diluting and carrying away the wastes of a modern society. Unfortunately, this use leads easily to abuse, as demonstrated by the condition of most of the rivers serving populated areas.

4. EFFECTS OF MAN ON THE RESOURCE

4.1 GENERAL EFFECTS

Interactions between the various natural systems with human systems of use, regulation, and management involves both human adjustment to and human modification of the hydrologic cycle. The consequences are two-fold.

On the one hand, Man can accelerate the process that would occur naturally. For example, the rate of erosion can be greatly increased through detrimental farming practices, and the expanding of navigation channels. The clearing of forests and plants, drainage of wet lands, and improper cultivation have significantly lowered the amount of ground water supplies. Clearing forests and grasslands increases runoff and erosion, thus preventing seepage into the ground and so causes a greater frequency of floods. Moreover, fish life can be destroyed by the use of certain minerals and their subsequent discharge into rivers and lakes.

A second set of consequences are those which do not occur in Nature to any marked degree. This occurs particularly with the construction and development of river control devices. In many instances the storage of water in a reservoir raises the temperature of that water, and consequently affects the normality of the fish life habitat. On a large scale, man-made storage of water may profoundly influence other elements of the ecological system. Alterations in weather and the general biological environment adjacent to the project may be induced to a marked degree. Agricultural practices, in particular, might suffer severe consequences. Such fears have been expressed in the debates initiated by the North American Water and Power Alliance (NAWAPA) proposal in which a large portion of southeastern British Columbia would be flooded and water stored for subsequent export to the United States.

Secondly, increasing concern is being directed towards efforts that would consider the practicality of water transfers from one river system to another in meeting regional demands for a stable and abundant supply of water. However, caution must be executed in such programs and recognition made of the interactions between water and its related resources. When a river is diverted from one channel to another ultimately, free passage of fish along this new path is affected. Such actions may be disastrous. Recent experiences are on record to support this claim.

With the building of the St. Lawrence - Great Lakes Seaway project, over 2,000 miles of river and lake channels were opened for navigation, not only for "foreign" ships and barges, but also for "foreign" species of fish.

In time, the waters of the system were infested with lamprey eels, a "fish-eating" species which eventually depleted the native stocks of bass, pickerel, whitefish, etc. which had swam in these waters. However, steps have been taken, and progress has been made in part through restocking procedures, using land-locked salmon species rather than that which existed originally.

Thus, it can be concluded that the greater the number of human alterations and the larger their scale, the more complex the interaction between water and its related resources is likely to be, and the greater the risk of irreversible alterations. Conflicts of use in Canada, i.e. fish and power, fish and logs, power and recreation and so on, which imply an intricate and complex interaction, not only among physical systems but also in relation to the human systems, which affect or are affected are important considerations in the evaluation of water supply and demand. Furthermore, erosion and diversions play a significant role in determining the location and magnitude of water uses.

4.2 THE IMPACT OF CHANGES IN TECHNOLOGY ON THE WATER RESOURCE

a. Introduction

New avenues, opened through technological developments, affect, directly and indirectly, the ratios of water use per head of population and per dollar of output, and thus the aggregate demand for water.

The actual application of new technology is dependent upon some particular incentive that it creates in a given set of cost conditions. Or, existing application potential might become feasible if the cost conditions related to traditional processes suddenly start to show appreciable rises. New technology applications are, then, clearly dependent on tensions between supply and demand on the one hand, while useful new applications stimulate shifts in the demand and supply situation on the other hand. This mutual and reciprocal influencing might well suggest the existence of a vicious circle. In fact, this "circuling" is not uncommon in many economic processes. The application, then, of a new technology will generally find its way into practice only slowly.

Technological changes have impact on the demand for water through:

- new products
- new processes
- new, or different raw materials.

Possible relationships of these to the different water demands are illustrated in the following table. In all cases technological change may either increase or decrease the water use per unit.

Some changes of taste effect water demand indirectly; they might be just as important as the direct effects. This category involves change of public preferences for desired goods and commodities. For example, the shift from white paper products to multi-colour products has resulted in a significant increase in the gross water used in the production process.

TABLE 2. Technological Change and Water Demands

	Type of Technological Change		
Water Demand	New Products	New Processes	New Raw Materials
Industrial	X	X	X
Domestic and municipal	X	X	
Water-based recreation	X		
Irrigation agriculture	X	X	
Waste dilution	X	X	X
Navigation	X		
Hydro-electric power generation		X	

Note: Blank compartments indicate negligible impact on the water demand.

b. Water Treatment and Recirculation Technology

In the case that an increased use of water has made it a relatively scarce good, the cost of water in a production process might be reduced by recirculating the water once it has been withdrawn from the source of supply. This application of technology provides probably the most effective reduction in water intake. The ratio of water use to water consumption can be largely increased, but this will only be realized under the external pressure of increased costs of new water intake.

> The Kaiser Steel Mill, California, U.S.A., is an example of this application. Extensive recirculation decreased the use of water per ton of steel produced from 35,000 gallons to 1,400 gallons.

Treatment of discharged water will not be brought about by production cost considerations, but rather by laws on pollution. The immediate effect of instigating such laws will be that more water becomes available for immediate re-use by downstream consumers. Detrimental effects on the eco-system will be halted and prevented. The cost to society as a whole will, undoubtedly, be lower in the long run by further improvement and wider application of the water treatment technology.

Water treatment and water recirculation are practical techniques that increase the usefulness of the water quantity that is naturally available. The net effect of these applications is comparable with an increase in water supply. It should be set out here, that at present, the cleaning of many rivers and lakes is overdue, and that the construction of a large number of treatment plants and recirculation systems will be necessary to reach an acceptable level of pollution in these lakes and rivers. The effect of increasing the water supply will not be observable until this clean-up activity has been completed.

c. Problems for the Treatment Technology

Technological developments, invariably, never come alone. Along with them always come the unwanted side effects. Effects that gradually become recognized as being more than just harmless side effects.

The function of water as diluting agent and mode of transportation for domestic and industrial waste has been taken for granted until recently. It is not very likely that this function will become obsolete within the next 10 or 20 years.

The consequence of the use of water for waste dilution is that a continued technological development will cause the discharge of more and more chemicals and suspended solids in rivers and lakes per head of the population. It is questionable whether treatment plants will be able to cope with an ever expanding series of chemicals used by industries and domestic consumers. It is conceivable that a technological gap between the capability of treatment plants and the variety of chemicals and solids in the effluents could be of continuous expanding size.

d. Substitutions for Water

Water, in the manufacturing processes, is often used as a cooling agent or as a solvent. It is conceivable that technological developments could tend to replace water by another material or by an entirely different technical application, not because of the high cost of water, but because of considerations entirely separate from the cost of water.

New processes or just straight substitutions of water could be of importance in a technological sense. Their impact on the use of water is hard to evaluate at this moment. In general it seems logical that substitutions will only take place in processes where the quantity of water used is relatively small, and the extra costs of the better substitute are considered worthwhile.

It does not seem probable that users of huge quantities of water will switch to water substitutes in the foreseeable future. Water, even if its price would be increased, is still a very cheap commodity.

e. Water in Electric Power Generation

Important withdrawal users of water are the thermal electrical power plants. Consumption per kilowatt-hour will vary from 0.3 gallons in 1965 to 0.1 gallons in 2020. Substitutions of water by some other fluid in a closed circuit system would affect the water use greatly.

Nuclear Power plants have huge cooling requirements. As noted before, new developments in the cooling technology would have beneficial effects, in particular in relation to a side effect that is considered to be an important threat to the ecological system: the thermal pollution.

Technological developments indicate a greater use of nuclear power generation. While hydro generation produced 82% of all electrical energy in Canada in 1966, this will have dropped to only 44% in 1990. In that year, nuclear plants will produce 32% of all electrical energy.

No basically new energy form will come into general use within the next 20 years. However, trends towards greater efficiency in transportation and utilization of energy will continue. There will be no new means of energy transportation in the foreseeable future. Only the provinces of Quebec and British Columbia have hydro potential left at present. The National Energy Board expects that hydro potential in these provinces will be fully utilized by 1985.

In conclusion, technological development will cause a shift in demand from flow uses (hydro power generation) to withdrawal uses for thermal power generation. This will increase the demand in the more critical sector of withdrawal water uses.

f. Methods to Increase Supply

On a nationwide scale there is an adequate supply of water. Shortages are always regional. Technology could assist in diminishing shortages by application of new methods in various ways.

Artificial aquifers could be developed for the storage of peak flows, and thus provide a better distribution of supply over the season.

Water supply, in certain areas, could be boosted by an increased precipitation through cloud seeding.

The prospects of increasing supply through the application of water-conservation techniques seems good. Monomolecular films are being developed to control evaporation and field tests are being undertaken in Southern Alberta. This technique is valuable in particular, for the more arid regions.

The transportation of water from an over-supply to a shortage region is not a new technology. However, there was a great tendency to consider dam and aqueduct construction as the only solution for obtaining a net increase in supply. Developments in pipeline technology seem a logical consequence of the intense interest in the entire field of pipeline transportation today.

Saline-water conversion processes have shown important cost reductions in the last 15 years. In all likelihood this trend will continue in the future. Applications include the treatment of seawater and also the treatment of saline groundwater. Increasing salinity of inland lakes might warrant another application of this technology.

5. ACTION BEING TAKEN TO PRESERVE THE WATER RESOURCE

There are a variety of mechanisms or activities which are being translated into action under various categories for preserving the water resource which are as follows:

Category	Mechanism or Activity
I. Influence Final Demand Sector (Consumer desires for goods & services which pollute)	1. Formulation of a proposal for an environmental tax on polluting goods and services and on effluents;
	2. Education of the public to influence attitudes towards consumption and cleaning up waterways;
	3. Restriction on the use of certain goods and services - e.g. use of DDT;
II. Production of Goods and Services	4. Controls on the manufacture of goods - e.g. restriction on the formulation of detergents;
	5. Incentives to change designs and processes - e.g. loans and subsidies to achieve non-polluting products;
	6. Incentives to use by-products and re-cycle wastes - e.g. effluent discharge fees.
	7. Requirements for ecological tests of new products;
	8. The development of national criteria for the environment - e.g. ambient levels for water (air, soil and plants);
	9. As a result of these criteria, the establishment of national standards;
III. Government Apparatus	10. Consolidation of environmental agencies into manageable, sufficiently inclusive departments;
	11. Explicit statement of overall environmental quality objectives;
	12. Formulation of total environmental strategy;
	13. Re-allocation of fiscal and human resources to higher priority aspects of the environment defined by the strategy;
	14. Problem-shed planning, e.g. comprehensive river basin planning;
	15. New improved legislation and judicial machinery;
	16. A Federal-Provincial agency to co-ordinate policies and programs toward commonly defined objectives;
	17. International standards of pollution control applicable to all countries.

IV. Direct Public Influence

18. Encouragement of anti-pollution pressure groups;

19. Dissemination of information in a wide range of environmental water including preservation of water resources;

20. Education to create an "environmental ethic" in young Canadians;

21. Courses, training programs, extension programs, use of mass media to increase environmental awareness.

6. SYNOPSIS

Everything originated in the water,
Everything is sustained by water.

Goethe

Canada has close to one-seventh of the world's fresh surface water supply and about 9 per cent of the world's total flowing water. Set this against a population of less than one per cent of the world's total, and it can be seen that we have over 10 times as much water per capita as the average in the rest of the world.

With such an abundance of water in Canada, why should we worry about conservation and preservation of our water resource? The answer to this question is tied in with several problems. For example, our 22 million people are not spread uniformly over our entire country. Ninety per cent of us live within 100 miles of our southern boundary. In fact, more than half our population lives within the basin of a single river -- the St. Lawrence-Great Lakes system. More than 80 per cent of our industrial activity takes place in this same river basin. In spite of the fact that we have much water there are certain areas or regions of Canada where water shortages are being experienced i.e., the dry interior valleys of British Columbia, Southern Prairies and Southern Ontario. There is evidence of ground water levels falling and many streams and springs running dry according to recent surveys in various parts of Canada.

What steps are Canadians taking to conserve water?

Farming methods to conserve moisture have been developed in Western Canada by the use of summer fallow supplemented by cultivation methods to increase filtration, and by the construction of storage ponds to catch spring run-off. Field shelter beds to hold more snow are also being used to conserve moisture. One of the most important methods of improving the moisture-holding capacity of the soils has been to increase the organic matter content of our mineral soils by the use of trash cover. The increasing flood problem in Canada has called for carefully planned conservation schemes over our watersheds. Main control factors have been provided in terms of reforestation, grass cover, farming methods to control

run-off, and dams on tributaries for water control measures. On some of our rivers the erosion of the banks is a serious problem. Most provinces have taken proper conservation measures to protect the banks against livestock or floods. Much work has also been done to control gullying through the study of watersheds. A great deal of research has been done by industry to recycle water and wastes but the tremendous advances in new industrial processes with complex waste products are constantly presenting new problems.

How have our steps been adequate in the conservation of water? Conservation or "wise use" of water in Canada has had many difficulties in pursuing its objective. Single purpose projects in the past have failed to consider downstream user benefits or disbenefits. Irrigation, water storage reservoirs and dams have in many cases either depleted water or flooded out wildlife habitat, eliminated fish spawning and presented many other problems. The drought years in the Prairies during the 1930's brought about an awareness for the need for conservation. The hundreds of thousands of projects that have taken place in the last four decades are evidence in support of this claim. The awareness for conservation has also brought about the concept of integrated river basin development and provision of comprehensive plans for development. This approach has taken into consideration all the conflicting uses of water and its interrelationships within a river basin. It also ensures that all costs, benefits and beneficiaries are identified and that ecological and environmental consequences have been considered.

There has been a definite inadequacy of legislative controls and laws to prohibit the misuse of waterways and a lack of coordination mechanisms between institutions to achieve conservation objectives.

Future action needed.

Future action to provide conservation of the water in Canada may be summed up as follows:

- Education of the public to influence attitude toward cleaning up and protecting waterways and in the wise use of water.
- Incentive to re-cycle wastes and water.
- Development of National criteria for environmental ambient lands.
- Establishment of National standards.
- Consolidation of environmental agencies.
- Explicit statement of National Environmental quality objectives.
- Provide a National Environment Policy.

CONSERVATION OF NONRENEWABLE RESOURCES

CONTENTS

CONSERVATION OF NONRENEWABLE RESOURCES

1. INTRODUCTION

There is no question but that "conservation" is "good" and that most people are in favour of it. However, many are beginning to recognize that conservation is not such a simple matter and that, in particular, conserving one thing may require the loss of another. Nevertheless, even they, if they could, would like to conserve both. This bias towards conservation is not just a moral dictum; rather it rests on the very rational foundation that the things we are conserving have value to us and that they are likely to have value to those who will come after us. Of course, less tangible human values play a significant role too, but for nonrenewable natural resources at least the prime consideration generally stems from actual or potential value in use.

Certainly this is the case for minerals. It is almost superfluous to describe the value of minerals to man. In fact, modern civilization is hardly conceivable without the structural minerals we use for construction, the chemical minerals we use for fertilizer, or the energy minerals we use for power. Even the important process of technologic substitution generally involves a shift from one mineral commodity to another, not a shift from a nonrenewable to a renewable one. Every developed nation has been built upon minerals, and every developing nation foresees its growth through minerals.

For Canada, then, which partakes of the characteristics both of the developed and of the developing world, minerals are doubly important. Like every other developed nation, Canada consumes vast quantities of mineral products and exports many finished products. Already its per capita consumption of energy is the third highest in the world, and much of this energy is based on the mineral fuels. On the other hand, like many developing nations, Canada is a primary producer with about 7 percent of its GNP and 32 percent of its export earnings coming from minerals production. (In coincidental balance with its energy consumption position, it is also the third largest mineral producing nation in the world.) The nation must therefore bear continually in mind a variety of tradeoffs, such as those between exporting and conserving for later domestic use and accepting environmental degradation in Canada for the things that exports can earn.

Yet Canada's problems may not be so unique. Rather they may simply be a paradigm for the world that seldom becomes explicit because today mineral producing and consuming nations are generally different. To the extent that development rests on minerals, mineral conservation is the concern of every developed or developing nation. In many ways, the problem of mineral conservation is the conservation problem par excellence. We cannot have modern civilization without mineral extraction and consumption. Yet such extraction and consumption not only involves depletion and eventual exhaustion in an economic if not a physical sense, but in every case simultaneously involves environmental change. You can no more expect a mineral

deposit to regrow than you can mine it without affecting the environment because it itself is a part of the environment. Now one cannot at this stage imply that either exhaustion or environmental change is good or bad (which is admittedly a bit contradictory given that conservation is good). Such valuations must be deferred until consideration has been given to what has been gained and what has been lost because of production and use of minerals. Clearly, in some cases exhaustion and environmental change is necessary and acceptable; in others they must be regarded as waste and degradation. One way in which to begin separating these several strands is to review the attitudes with which conservationists have viewed nonrenewable resources and how these have changed over time.

2. NONRENEWABLE RESOURCES AND THE CONSERVATION MOVEMENTS

Traditional conservationists have never been terribly comfortable in dealing with nonrenewable resources--essentially fuel and nonfuel minerals. Indeed, there does seem to be a contradiction in the very idea of conserving something that can't renew itself, but minerals are natural resources and they are even more subject to exhaustion than trees and fish. The dilemma is compounded because there does not seem to be any easy way of applying the conservationist's typical policy prescriptions--policies like maximum sustainable yield--to minerals.

The First Conservation Movement of the Teddy Roosevelt era in the United States settled on a rather simple dictum about nonrenewable resources; use them as little as possible, which really meant use them as slowly as possible. This principle was based on the idea that, since mineral resources were bound to be exhausted by man eventually in any case, the best policy was to postpone that dire day into the distant future. For the most part, the industrial need for minerals was not itself questioned, nor was much thought given to technology. It was simply a philosophy of hoarding.

By the time of the Second Conservation Movement of the 1930's in the U.S., the growth of modern industry had made the earlier dictum look a little ridiculous. The main conservation tenet therefore shifted to one of wise use, to ensuring that whatever minerals were produced were used to their maximum potential. The objective was to avoid waste and encourage re-use. The change was based on the apparent absence of any significant exhaustion on a global scale despite heavy rates of consumption but the recognition that there was a shift towards lower grades (i.e. higher cost) source of supply.

We are now in a Third Conservation Movement, apparently as a nearly worldwide phenomenon, and an even more important shift can be noted than that between the First and Second Movements. Today's concern is not with conservation of the minerals at all, but with the pollution attendant upon their production and consumption , that is, with conservation of environmental resources. Mining is a problem not because of exhaustion but because of temporary or permanent damage to the renewable resources with which the nonrenewables are interrelated in nature. These damages have been widely described and, except for the brief listing in the two Appendices, will not be catalogued here.

Actually, of course, carefully expressed, some truth can be found in the views of each of these conservation periods. Moreover, it appears that the Third Movement is beginning to shift its ground and, in effect, become a Fourth Movement, one which emphasizes not only pollution resulting from production and consumption but also the value of high rates of production and consumption themselves. Questions are being raised of the value of not producing and, even more strongly, of not consuming, say, the materials needed for a second (a first?) car, or the land and energy needed for single-family homes. The shift from the Third to a Fourth Conservation Movement is also receiving some of its impetus from suggestions that there may be global problems attending our increasing rates of material and particularly energy consumption. In a fundamental sense of course, apart from sunlight, the oceans and the atmosphere are the ultimate nonrenewable resource. Unfortunately, as indicated by many winters, neither the cause nor the effect of observed changes is very well known, and even some of the observations are ambiguous (1).

In one sense, the policies implied by such a Fourth Conservation Movement will be a return to the principles of the First--slow down consumption--but for very different reasons. For the first time in modern history, economic growth itself is being questioned. The objectives of the Fourth Conservation Movement are not to conserve minerals for future generations, but to conserve values that would be lost if they continue to be produced and consumed at rates typical of developed nations and even more so if these rates are emulated by developing nations.

Unfortunately, it would take us too far afield to discuss these trends and to reflect on what directions they imply for world development. What is clear is that nonrenewable resources are at the heart of modern conservation problems. The following sections are intended to indicate the nature of the present conservation opportunity for nonrenewable resources and something about possible ways to achieve that opportunity. Throughout it will be helpful to keep in mind the several different levels of conservation that have been implied above. The most fundamental question is:

i. How much of any nonrenewable resource should be produced and consumed in any time period, i.e., questions of appropriate rates of economic growth and per capita incomes?

Then, given that we are going to produce and consume some nonrenewable resources, two further questions follow:

ii. How can we best use whatever nonrenewable resources are produced in any time period?

iii. How can we best protect the renewable resources associated with the nonrenewables in nature?

Of course, each of the secondary questions can be further subdivided in a number of tertiary ones. For example, the need for efficient use involves:

(a) higher recoveries of nonrenewables at the mine and at each subsequent stage of processing,

(b) less nonrenewable inputs per unit of final product (less in-plant scrap, lower heat losses, etc.), and

(c) improved recycling of final products after use.

The need for protection of renewable resources involves:

(a) decisions about specific sites for production,

(b) controls over production processes, and

(c) reclamation of the site after production is complete.

Let us now go on to say a few words about the nature of nonrenewable resources and their importance to man.

3. MAN'S EFFECT ON NONRENEWABLE RESOURCES

If one uses words literally, most natural resources are in fact nonrenewable. That is, they are subject to exhaustion if man is careless enough of his production and consumption plans or if he decides in his wisdom to seek exhaustion. Perhaps the most obvious example of "renewable resource" that has been exhausted involves the 150 species of birds and animals that have become extinct during man's brief tenure as master of the earth. It is equally possible to move fish, forests and soil into the nonrenewable category under appropriate circumstances. Moreover, as indicated above, given the possibilities for creating dynamic disequilibria in the atmosphere or in large bodies of water, little apart from sunlight would appear to be absolutely renewable.

In common use, however, the term nonrenewable resources can conveniently be restricted to those resources for which exhaustion in some sense inheres in production and use. Only minerals--both fuel and nonfuel--readily fit this more limited definition. (Open space wilderness and special-purpose sites, as for hydro dams, can also be considered depletable in that they gradually get used up or are devoted to alternative purposes. Except for the last, measurement problems make it difficult to apply economic principles directly to them.) For all practical purposes, once a mineral is mined that much of our natural wealth has been depleted forever. Yet, looking now at this definition in more detail, it is possible to question whether minerals are in fact so nonrenewable in any fundamental sense. For one thing, technological advances in modern times have been such that exhaustion, while real enough at individual sites, is not a very important problem on a world wide basis. The most obvious effect of the advent of exhaustion should be a steady increase in price, and for very few nonrenewable resources can such a long-term increase be demonstrated (2,3). (The exceptions among minerals are certain major nonferrous metals, for which deflated prices per unit have been rising slightly since the 'thirties.) What has happened is that technologic

advance has in most cases more than made up for depletion so that we can now mine lower and lower grades of material at the same real cost (that is, the same inputs of goods and services per units of output) once required for much higher grades (4,5). Similarly, exploration techniques have become more efficient so that, paradoxical though it may seem, per unit of mineral discovered, it may be cheaper to explore for minerals today than it was when prospectors were the main source of discoveries. Note in contrast that the life of non-mineral nonrenewables like open space and wilderness cannot be so easily extended or perpetuated by technology. Here again, there is the suggestion of a deeper conflict between the Fourth Conservation Movement and modern technologic society than was originally foreseen. While there may be ways to ameliorate the conflicts--angle drilling for petroleum to avoid additional land occupation or refilling of underground mines with tailings or slag to prevent subsidence and avoid surface disposal--many cases will remain where even these higher cost compromises will be unacceptable to at least a significant part of the population. Similarly, while in some cases appropriate reclamation practices may (not always) restore a mined area to a pleasing and/or productive state --in effect making the site a renewable resource--there will still be temporary losses that may prove unacceptable.

Returning to minerals, a second reason why at least some can be regarded as partially renewable involves the opportunities for recycling. Almost all nonrenewables that are used in structural ways or that form parts of goods can be used over and over again. Moreover, in contrast to many other recycled products, recycled mineral products are generally equally as good as primary ones. Fuels, of course, along with some uses like paint, cannot be recycled (though in effect the breeder reactor would provide the same result for power reactors).

This view of nonrenewables is quite in accord with modern economic thought. Those theoretical economists who looked at the problem most carefully finally concluded that for the most part the distinction between renewable and nonrenewable resources was empty, that so far as conservation was concerned (or, more accurately, investment in conservation), there was no distinction to be made between them (6, 7, 8). By the same token, then, apart from questions of military security, there was little or no need for special public conservation policies applicable to mineral resources. Moreover, one might pose the question a little differently and ask whether we--i.e., the present generation--are leaving future generations with enough of a stock of minerals to enjoy adequate incomes. Again, both on theoretical and empirical grounds there seemed to be little reason for singling minerals out for special attention (9).

4. CURRENT ACTION BEING TAKEN

Thus, the view of modern economists, i.e., the view that there is little or no important difference between renewable and nonrenewable resources, comports with the emphasis of the Third Conservation Movement. The public certainly accepts that renewable resource conservation is far more important than nonrenewable resource conservation. And, in truth, so far as anyone can observe things, it is the nonrenewable resources that are being degraded. Two Appendices illustrate this point. Appendix One lists environmental problems resulting from mineral resource production and consumption. Appendix Two presents a partial catalogue of problems arising in the several provinces of Canada. Much more detailed catalogues of mineral-related problems, including many

effluent measurements, have been prepared, notably in the U.S. However, like these two Appendices they all illustrate ways in which man has had an effect on renewable resources through his drive to get nonrenewable ones. Finally, if one considers the institutional responses of the past few years--essentially air and water oriented--it will be seen that these too involve the protection of renewable resources (10). For example, among recent acts passed in Canada, the Canada Water Act is of overriding importance to the mining industry both because it introduces new concepts and because it is becoming the standard to which other laws conform. Passed in June, 1970, this Act has two fundamental provisions:

i. authority to develop comprehensive water resource management plans for those areas where there is a 'significant national interest", and

ii. authority to create a Water Quality Management Area (WQMA) in any area where an 'urgent national concern" is identified.

The WQMA has particularly wide powers. For example, under its authority a joint agency can be set up to regulate water use by establishing standards, regulations, and even effluent charges; alternatively the agency could build and operate its own treatment plants.

At the same time as new laws like the Water Act are coming into force, older laws are being reinforced. Notable are amendments to the Fisheries Act which state that the Minister has authority to review plans to construct, alter, or extend any undertaking that will affect either areas that fish frequent or waters that flow into such areas. The Northern Inland Waters Act specifically vests in the Crown all rights to both surface and under-ground water in the Yukon and the Northwest Territories. The Arctic Waters Protection Act asserts Canada's intention to regulate coastal activities for the purpose of environmental protection for a distance of 100 miles from any Canadian arctic land area.

Finally, given that the bulk of air pollution arises from the combustion of fossil fuels, from the smelting of sulphide ores and from steel production, the proposed Clean Air Act is likely to have an even greater long-run impact on the mineral industries (including mineral manufacturing) than the other acts that have been passed to date. The exact wording of the bill is not yet known, but the approach will probably be national in scope to ensure that pollution is not merely transferred from one region to another and will be based on three kinds of standards: desirable, to indicate optimum states of air cleanliness; acceptable, to indicate general limitations for existing plants; and permissible, to serve as guides in short-term emergencies.

Thus, in Canada, as in most other countries, new institutions focus all but exclusively on renewable resources. Among the few exceptions are the Solid Waste Disposal Act of 1969 in the United States, which includes some attention to recycling, and the proposals for a National Materials Advisory Board, also in the U.S. (11). Perhaps the "energy crisis" will refocus some attention on the minerals, but even here the shortages and higher prices stem from attempts to secure less polluting forms of energy rather than from any absolute exhaustion.

5. SOME DEVELOPING QUESTIONS ABOUT PRIORITIES

If the distinctions between renewable and nonrenewable resources are so vague, so also are the distinctions between any principles applicable to conservation of mineral and environmental resources. Skipping until later the fundamental question of whether to produce, let us look in a little more detail at the two aspects of conservation because we may be devoting attention to only half of the problem.

The drive to conserve the minerals stems most directly from the fact that mineral deposits are subject to exhaustion. Although with advances in technology world mineral potential may be nearly limitless, the quantity and quality of mineral resources available at a particular locale are fixed. In general, with better conservation, exhaustion of minerals will be postponed and along with it the problems of declining mining communities and ghost towns. The fact that many developing nations rely heavily on mineral export earnings only reinforces this point. Also it is not clear to what extent future cost increases for minerals may impose real limitations on development. This question, which can possibly be ignored in developed nations, must be regarded as critical in nations or regions of less-than-adequate per capita incomes.

Moreover, to the extent that minerals are conserved, nonrenewable resources are also to be protected. For example, the secondary recovery of metals in the form of scrap can be justified both because it helps avoid land pollution from excessive solid waste disposal and because it encourages more intensive use of the mineral resource itself. Similarly, efficient use of mineral technology compared with highgrading not only increases recovery but by prolonging mine life, avoids disturbance of the environment elsewhere. Unfortunately, even here tradeoffs must often be established. As emphasized in an earlier publication (12), it is not always possible to maximize conservation of a mineral and at the same time maximize conservation of environmental resources. There may at times be conflicts between the two goals, at least after some point. For example, in order to avoid leaving some mineral in the ground and thereby wasting it, a wider or a deeper pit may have to be dug, which will increase the effect on other natural resources. In contrast, the use of in situ cyanide leaching to recover small amounts of finely disseminated gold--a technologically efficient method--is deliberately foregone in order to protect land and water resources.

Thus, it is not surprising that a great deal of confusion has resulted from loose use of the term mineral conservation. Some writers are talking about the mineral resources, some about the associated environmental resources, and some about both. Perhaps, however, by developing some common concepts we can bring our ideas about the two dimensions into a single framework.

To retreat to some jargon adopted by economists from lawyers, air and water and sometimes land are common property resources. They are "common" in that they are owned by no one, though it is far better to regard them as being owned equally by everyone. In any event, the firm tends to regard such common property resources as free for its use or perhaps available at

very low cost, and as a result they become ideal reservoirs for waste disposal; anything can be either passed off into the local atmosphere, released to a nearby watercourse or dumped onto the land. So long as these environmental resources can handle the residuals from mining with no observable deterioration, there is no problem, but very quickly the impacts become perceptible and we have a pollution problem. As emphasized by many observers, we will continue to have pollution problems so long as the common property nature of the environment is not explicitly recognized and so long as there are no institutions created to restrict and control (and, in most cases charge for) demands placed upon it.

Turn now to the companion problem of conserving minerals themselves. In a sense, this problem is the time counterpart of the spatial problem just discussed. That is, pollution arises because firms do not need to take account of their use of the spatial environment at some point of time, and as a result wastes spread too far laterally. In the case of the minerals, inappropriate recovery decisions may be made by firms because they try to optimize their operations over a shorter length of time than is best for the community. In some sense then, a socially inefficient time rate of mineral production and use can also be treated as the nonrenewable resource counterpart of the common property problem for renewables.

To be more specific, a mining company will not invest in a new property or cease investing in existing mine or region whenever it does not anticipate a rate of return that is variable but that is surely no less than 12 percent per annum. It will actually close an operation when the returns are insufficient to cover out-of-pocket expenses. The same will apply to decisions about recovery of byproducts from main products or about recovery of metals from scrap. Yet any of these decisions will serve to lengthen the life of a resource.

However, even apart from environmental issues, from the community point of view there may well exist rational reasons to desire a longer time horizon. To take the most obvious case, a community may exist because of the mine, and a closure will require expenditures for relocation as well as losses in the public capital investment of streets, schools, and the like. In a more complex example, a potential byproduct may occur in a metallic ore, but not be recovered by the firm because it will not pay in a conventional accounting sense. However, if the Nation has to import this commodity and if it has excess labor and capital, it may be national policy to promote such recovery. Finally, to return to the example cited above concerning scrap, note that there is no incentive for the firm to use scrap beyond that amount that is commercially feasible on its own terms, nor does the metals firm have to pay for the final disposal of the products it produces (11, 13). Neither has reason to take account of either the costs of scrap collection or of any benefits from mineral resource conservation. If they did, the products themselves might be designed very differently. For example, it has been suggested that simple redesign in an automobile would make it much more valuable when it is later scrapped.

Now, just as with environmental questions, none of these examples is intended to prejudge the answer. Surely, for example, there is little to be gained by preserving every mining camp or investing labor and capital inefficiently. However, the point is that there are good reasons to begin asking the questions explicitly, for at present they are answered on a willy nilly basis. When such questions are posed together with those about environmental protection, they become truly pressing. In short, institutions are needed to consider and control BOTH the method AND the time rate at which mineral resources are being produced and consumed.

6. CONCLUSION

Clearly, few are yet satisfied with the state of environmental protection during mineral production. More needs to be done along one of the lines suggested by the current laws. In some cases no doubt this will involve prohibitions of the recovery of nonrenewable resources in order to protect the renewable ones, and in many cases it will require that the recovery of nonrenewable resources will become more expensive. However it is effected there is a great awareness of this problem and a drive to do something about it.

The same can hardly be said for conservation of minerals despite the fact that mineral conservation might go further towards protecting the environment than many direct approaches. Moreover, if economic growth is no longer to be so highly valued, at least in developed nations, per capita rates of mineral consumption might conceivably flatten out or even begin to decline (1, 14). This would not imply that minerals are any the less important to our civilization, and statements decrying current conservationist sentiments on the basis that the benefits of mineral extraction have hugely outweighed the adverse effects, are misinformed and misleading. It is, as usual in economic issues, not a question of totals but of marginals. The real question is whether additional units of production and consumption are as benevolent--on a net basis--as past ones have been. It is unlikely that we shall go on assuming, as we have in the past, that all demands for nonrenewable resources are equally meritorious.

What is required, in order to make such policies something more than arbitrary, is a much more careful social accounting system. This system would have to reflect as well as possible the net social gain from additional units of consumption. This means it would take into account ill-effects attendant upon its use or consumption--effects like more congestion, noise created, and the like. Moreover, the price of materials that go into making up this commodity would take account of ill-effects accompanying their extraction from the earth--effects like environmental degradation, temporary land-use changes and distribution shifts. This identification of the "costs of economic growth", including both production and consumption costs, would provide an enormous incentive for conservation of both mineral and environmental resources.

Among the many measures that have been suggested to effect such conservation, are sequential (rather than multiple) land use, rural zoning, safe minimum standards, (avoiding irreversible actions) and pricing to

reflect disposal costs (7, 15, 16, 17). However, while appropriate administrative institutions can be readily envisaged, it will be less easy to design a system to make the necessary measurements of value, to make provisions for the inevitable resulting shifts in income distribution, and, finally, to win public acceptance for the new values. Yet as Prime Minister Trudeau recently stated with reference to environmental problems in Canada (18, 19), "There are no easy answers to these questions for the problems they pose are in many instances contradictory. But that does not mean there are no answers."

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APPENDIX I

MAJOR MINERAL ENVIRONMENTAL ISSUES BY COMMODITY

Coal

1. Land reclamation.
2. Disposal of waste.
3. Atmospheric pollution from coal combustion.

Oil

4. Problems associated with bituminous sands should this become a massive industry.
5. Oil spills, particularly related to marine transportation.

Uranium

6. Radiation in underground atmospheres.
7. Medical relationship between dust and radiation levels in mines being related to disease.
8. Waste disposal, particularly because uranium is a hydrometallurgical operation with not only the usual contaminants of other mineral processes but with radiation hazards as well.
9. In the longer term, should Canadian capabilities be extended in the field of enriched uranium and re-processing of spent fuel, environmental problems would ensue.

Nonferrous and Ferrous Metals

10. SO_2 and dust emissions from roasting and smelting sulphide concentrates (copper, nickel, lead, zinc, silver, and iron).
11. Contamination of ground waters, streams and lakes by mine waters, and by drainage and seepage from tailings ponds.
12. Storage of waste products from milling and smelting; commonly involves a space problem but also in special cases such as arsenic and mercury a disposal or containment problem.

Industrial Minerals

13. Reclamation of sand and gravel pits and stone quarries.

Substitution problems (not connected with mineral production operations).

14. Declining use of lead compounds in gasoline.
15. Declining use of mercury in caustic soda - chlorine production.

APPENDIX II

SELECTED MINERAL ENVIRONMENTAL ISSUES IN CANADA BY PROVINCE

Excerpted from a special report to the Policy Research and Coordination Branch (then the Policy and Planning of what is now the Department of the Environment. The list is of course not complete but does highlight the more important problems that have come to public attention.

British Columbia: The major source of mineral pollution is surface mining. Mining operations at Fort Rupert on the north part of Vancouver Island are reported to contribute to water pollution at Quatsino Sound; further mining operations have been proposed by Utah Mining Corp. In the Kootenay region siltation from coal strip mine operations is proving harmful to local sports fisheries; some proposed sites could damage big game population as they are coincident with important ranges and mineral licks. At Kimberley gypsum as well as sewage is dumped into the St. Mary River.

Alberta: Mining activities for coal, oil and natural gas constitute a source of pollution. Oil drilling has not caused serious problems to date because it has taken place in a temperate region and has been well regulated. Unpleasant odors from oil well sites have been reported in the Joffre area, southeast of Lacombe. Surface mining activities, particularly for coal, cause problems near Wabamun, Forestburg, Dodds and Hanna. There were no reclamation efforts at older operations now closed. Near the park north of Jasper, once coal deposits were discovered, park boundaries were redrawn so as to exclude mining operations. Exploration in the balance of the park continues to affect wildlife.

Saskatchewan: Cement plants, widely located, tend to destroy nearby foliage. Potash mines also contribute pollution. Pollution of the Saskatchewan River is most serious, and part comes from oil refineries.

Manitoba: There are mine tailings in rivers and lakes of northern Manitoba, and considerable foliage has been killed by gaseous emissions, especially near Cook Lake, Ospwagan Lake and Burntwood River. There is considerable smoke from refinery stacks in Virden.

Ontario: Air pollution at Sudbury has caused extensive damage to vegetation and contributed substantially to soil erosion. (References to mining in Ontario and Quebec are necessarily abbreviated because of the heavy urbanization and industrialization of these two provinces). Mine tailings cover large areas in the gold mining region. Acid, silt, and metallic ions are present in rivers.

Quebec: Mining poses general problems throughout the province. In the Sherbrooke-Ascot region the leaching of abandoned gravel pits is a problem. As in Ontario, large areas are covered by tailings and water courses contain mining and processing effluents.

New Brunswick: Base metal mining operations affect the Little River and the Tomogonops Tributary of the Miramichi, with resulting levels of copper and zinc that are harmful to the local salmon fishery. Oil spills cause coastal pollution.

Nova Scotia: Mining operations are a general cause of water pollution, which, as in the other Maritime provinces, is a more serious problem than air pollution. In Sydney metals processing contributes to the contamination of the air mantle over all Cape Breton and Westmount. At Apringhill the coal mining creates dust pollution. Offshore oil spills are a problem. Copper, zinc, and sulphuric acid are present in the rivers of the province as a result of mining.

Prince Edward Island: Accidental oil spills have occurred along the coast.

Newfoundland and Labrador: Apart from oil spills, there is discharge of elemental phosphorus into Long Harbour and pollution of the Exploits River by some mine wastes. New refineries may pose additional problems because of siting.

PRESERVATION OF GEOLOGICAL SITES IN CANADA

CONTENTS

PRESERVATION OF GEOLOGICAL SITES IN CANADA

1. INTRODUCTION

Little attention has been given in Canada to the direct preservation of geological sites *per se*, though there are a few noteworthy exceptions. However, geological features of interest to the general public are protected where they are encompassed in National or Provincial parks and where collecting of rocks, minerals, and fossils, or the defacing of such materials, is forbidden except under special permit. The sites of many parks have been chosen because of geological features of scenic interest and these are thereby preserved for posterity. In some parks, though perhaps set aside for their floral, faunal, or other interest, it was the geological deposits combined with the climate that provided the setting for the park, and hence these deposits also receive some measure of preservation. A series of well-illustrated booklets, published by the Geological Survey of Canada (1-10) and written in layman's language, serve to impress the geological wonders of the National Parks on both tourists and local inhabitants. They also provide the essential scientific information that the reader may better appreciate the geological setting and his personal relationship with the environment. Several beautifully illustrated guidebooks to the geology and scenery of parts of Ontario have been published by the Ontario Department of Mines. (16,17,12) These serve the dual purpose of awakening the touring public to the geological wonders of the regions concerned, and to the importance of the mining industry to the economy. They also provide detailed information on sites for rock and mineral collecting, especially along the Trans-Canada Highway. Perhaps in the future certain rock and mineral occurrences, and even landscape features, will have to be specifically preserved, rather than serve as collection sites, but at present the stimulation of interest in, and appreciation of, the geology and landscape is in itself a desirable aspect of conservation.

2. PRESERVATION OF GEOLOGICAL FEATURES

Only in a very few places in Canada have attempts been made to control natural erosional processes, or to deter destruction by man, specifically to preserve or prolong the life of features or sites of special geological or related interest.

The famous main 'flower pot' on Flower Pot Island, off the Bruce Peninsula in western Georgian Bay, Ontario, is an excellent example of such direct action to preserve a natural feature. (5). The upward-tapering rock pillars or 'flower pots' are erosional remnants of hard, thick-bedded limestone overlying softer thin-bedded limestone, the latter occurring at lake level. Erosion of the strata along joints, and later differential erosion of the lower unit at the lake shore, have resulted in numerous pillars along the shoreline. To preserve the largest 'flower pot' the parks authorities have carried out masonery work at the base of the pillar and spread a waterproof capping of concrete over the top; the neatly preserved forty-foot structure thus remains to add its stark beauty, for some additional years, to the scenery of Flower Pot Island.

At Niagara Falls, Ontario, great care is exercised to ensure that no untoward action by man, including the collecting of fossils, may further affect the aesthetic qualities of the existing falls and gorge system. Of greater and more far-ranging importance in this regard is the passing of an act by the government of Ontario (15) "to preserve the nature of the Niagara escarpment against encroachment that cannot be restored". The act empowers the government to control all mining and quarrying activity along the escarpment and it specifically forbids any work in the uppermost two formations within 300 feet of the escarpment edge. The formations are defined in Geological Survey of Canada, Memoir 289 (12). Thus the face of the escarpment will not be further marred by the action of man. A further effort to preserve a part of the Niagara escarpment in toto has been the acquisition of land for a new Provincial park near Owen Sound on the Bruce Peninsula.

The erosion of the southern shores of Point Pelee Peninsula and consequent incursion of the lake into the interior ponds and marshes of the National Park, has been a matter of great concern in recent years. The Park area comprises the southernmost point of mainland Canada and the erosion threatens the existence of the geological feature itself as well as its contained unique eco-system. In an effort to prevent, or at least retard, the erosion of the natural beach and spit complex, specially-shaped concrete blocks have been placed on the beach at the water line.

A remarkable series of raised beaches in Agawa Bay, on the east side of Lake Superior, are now protected under the jurisdiction of the Ontario Department of Lands and Forests; exploitation of the gravels and destruction of the beaches is thereby prohibited.

In Nova Scotia a provincial act administered by the Department of Lands and Forests prohibits the removal of sand and gravel from a number of prescribed beaches as a measure for protection of the beaches themselves.

3. PRESERVATION OF FOSSIL SITES

Some attempts are now being made to preserve specific fossil sites in Canada. Near the town of Field, British Columbia, in Yoho National Park the Burgess Fossil Quarry (made famous by C.D. Walcott in a series of publications beginning in 1912) is now protected by the Park authority; collections may only be made under special permit. Cambrian-age fossils of soft-bodied animals and plants from this quarry are of world renown. In the same park, on Mount Stephen, a nature trail leads to a talus slope where excellent trilobite specimens are abundant. An official park sign requests that they be left in place for others to see, and certainly no major collections may be made without a permit.

In Alberta near the town of Brookes, the Provincial Government has set aside an area of badlands known as Dinosaur Provincial Park. One of the nature trails takes in a number of fossil bone sites where partially uncovered and preserved dinosaur remains are housed in suitably lighted buildings that the layman may see their relation to the enclosing beds. This helps promote an interest in geology as well as a better appreciation of the mounted dinosaur specimen and other related displays in the nearby Drumheller museum.

In southern Saskatchewan two important vertebrate fossil sites are protected on privately held lands. In one case in the Cypress Hills (Hunter site on the present Hanson Bros. Ranch) only bona fide collectors are allowed on the site thus ensuring some preservation of the Oligocene-age beds and the best use of the fossil bones. In the other case near Rock Glen (Kleinfelder Farm) a Miocene-age fossil site is well-protected and under lease to the Royal Ontario Museum of Palaeontology.

In the Gaspe region of Quebec, land that encompassed a well-known site of Devonian-age fossil fishes was recently purchased by the government of Quebec as a means of protecting the fossil beds from rapid exploitation.

In the normal course of landscaping around the headquarters of the Geological Survey of Canada in Ottawa, an outcropping of Coburg beds of the Ordovician-age Ottawa Formation would have been destroyed. Due to the efforts of a palaeontologist the beds were left exposed as a natural rock-garden outcrop, in a large part because of the occurrence of a rare brachiopod of international value in correlation of the enclosing Coburg strata. A sign denotes the name and age of the rocks.

4. GENERAL PRESERVATION MEASURES

In many parts of Canada, Departments of Highways, Forestry, Tourism, and Mines, Local Chambers of Commerce, Historical Societies and others have endeavoured to draw the publics attention to matters or items of general geological interest including landscape features; they have placed signs, plaques, or monuments at roadsides and other convenient locations. This action serves as a form of preservation through awareness.

The Alberta Society of Petroleum Geologists has placed appropriate signs marking the occurrences of such diverse geological items as the amygdaloidal lavas near Crowsnest Pass, the 18,000 ton glacial erratic at Okotoks, the Devonian reefs near Banff, and a brachiopod bed on the highway near Jasper. Also the Alberta Historic Sites organization and the Department of Highways have cooperated to post signs at a few places of geological interest such as the site of the disastrous landslide at Frank, Alberta, which wiped out part of that town, occupied 3200 acres of fertile land, and claimed 66 lives. Similarly in British Columbia an appropriate sign occurs beside the highway built over the debris of the landside near Hope, and another draws attention to the basalt columns in Keremeos Columns Provincial Park.

In Ontario, the Archaeological and Historic Sites Board has posted at a number of points of geological interest. For instance plaques and signs on the Niagra escarpment at Hamilton, on the Scarborough Bluffs at Toronto, and on Callander Bay, Lake Nipissing inform the public of the local geological setting and regional history. A bronze plaque, posted by the National Museum of Canada, on the folded and faulted Ordovician strata at Hogsback Falls on the Rideau River in Ottawa, similarly promotes public awareness of geological phenomena. More restricted are signs denoting specific rock type such as interesting outcrops of Precambrian rock at Bala, east of Georgian Bay and near Rossport, north shore of Lake Superior.

As is appropriate for a country of such extensive glaciation, bouldersized glacial erratics are widely used to bear plaques commemorating places or persons of note in connection with a wide variety of historical matters including the development of geological knowledge. A notable example of the latter is an ornate bronze plaque on a boulder in front of the Geological Survey of Canada in Ottawa. This plaque, bearing the likeness of Sir Wm. Logan, founder of the Geological Survey, was presented by the Twelfth International Geological Congress on the occasion of their meetings in Canada in 1913. This is a particularly fitting tribute to Sir Wm. Logan who clearly described the work of glaciers in the Lake Timiskaming Basin and in the Ottawa Valley as early as 1845, (14) only a few years after birth of the concept of continental glaciation and the year before Louis Agassiz himself came to North America. Glaciated surfaces may on occasion be preserved as points of public interest if uncovered in a convenient location. For instance a large exposure of heavily scoured and striated limestone on the campus of Queen's University in Kingston, Ontario was fenced off and left uncovered for public observation. Similarly a striated and polished outcrop was retained as part of a fountain display in Victoria, British Columbia and serves to enhance the natural setting.

Signs and plaques have been erected to denote matters pertaining to the mineral and mining industry in both Ontario and British Columbia. The discovery outcrop of the world-renowned Sudbury nickel mining area bears a cast metal plaque to commemorate that notable site. A plaque marks the site of Ontario's first gold mine near Madoc. The Bruce copper mine, near Blind River, abandoned prior to the Act of Confederation in 1867, is similarly marked as are some other notable abandoned mines. In a different vein, a bronze plaque in the heart of Cobalt commemorates Willet G. Miller, Ontario's first Provincial Geologist, and a pioneer in the development of that fabulous silver-cobalt mining camp (18). Old mines of historic interest are suitably marked in various places in British Columbia. For instance a cast metal plaque and accompanying signs point out the adits on the mountain side of the renowned Hedley-Mascot and Nickel Plate mines.

Similarly a plaque at the old Rossland mine points out the mine dump, tells of the ancient volcanic crater, and gives the production tonnage and values.

5. SYNOPSIS

Broadly speaking, very little has been done in Canada to preserve specific geological or physiographic features, stratigraphic sections, or fossil beds. For the most part signs or plaques are posted to promote public awareness through the efforts of dedicated scientists or local organizations, but governmental agencies have also recognized the aesthetic and touristic values of certain geological phenomena. The legislation for preservation of the Niagara Escarpment is a unique case in point. Less regional, but none-the-less important, are legislative acts to protect sea and lake beaches from destruction. The National and Provincial Parks are very real and direct measures to preserve the natural environment and these also serve to protect the contained geology both en masse and in detail.

Little regard has been given to the preservation of surficial deposits for groundwater recharge or storage; instead eskers, kames, outwash etc. are exploited for construction purposes near urbanized or industrialized centres. The better deposits of sand and gravel are commonly removed for construction materials, down to or even below the groundwater level, and the sites are then used for garbage or other waste disposal. Elsewhere sandy deposits are used directly as cover for garbage in an effort to avoid burning and consequent air pollution in built-up areas. Limitation, contamination, or complete destruction of important groundwater resources is thus inevitable and costly surface water systems must be installed, - and this at a time when pollution of lakes and streams is itself a problem of concern. It is clear that more far-reaching scientific and economic studies are needed before spoiling of such non-renewable resources is undertaken for short-term and possibly ill-conceived local gain. Surficial materials and glacial features, in some areas at least, must be recognized as integral parts of the natural environment rather than as raw materials for local, short-term use.

The layman cannot be expected to comprehend the physical environment around him and it is therefore the responsibility of individual earth scientists and scientific organizations to keep the public informed. The posting of plaques and signs to draw attention to geological features and sites is thus a commendable minor venture in the problem of conservation pertaining to the human environment

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THE CONSERVATION OF HISTORIC RESOURCES IN CANADA

CONTENTS

THE CONSERVATION OF HISTORIC RESOURCES IN CANADA

1. DEFINITION

Historic resources are scarce, often unique, non-renewable, tangible remains of man's past activities. They range from the archaeological evidence of the peopling of the New World to examples of 20th century architecture and technology; from archaeological and ethnographic specimens, through documents, objets d'art and antiques to buildings and large parcels of land. The thread common to all these remains is that they illustrate, in concrete form, man's past for the benefit of the present in facing the future. They are easily destroyed, all too often threatened and, once gone, can never be replaced.

By conservation is meant, broadly, all those activities required to understand the significance of these remains, enjoy them in the present and preserve them for the future. Implicit in this concept is human activity and intervention. An archaeological specimen, for example, may be well preserved underground, but in that state it contributes nothing towards human understanding or enjoyment; excavation, analysis and display are necessary before this can be achieved. Thus, the conservation of resources also implies their wise exploitation, i.e., their use in a fashion which contributes the maximum to the sum total of human knowledge while preserving the tangible remains for future generations to also enjoy.

2. VALUE OF THE RESOURCES

Whether from simple curiosity or desire to control his own destiny, man seeks to understand the universe and his place therein. Since our current state is clearly the result of all that has gone before, the historical disciplines constitute a major avenue towards such an understanding. By seeking to learn how we have come to arrive where we are, we hope to understand ourselves better, to avoid repetition of past mistakes, and to profit from experience in order to cope more ably with the problems of the future.

While the practice of the historical disciplines is increasingly becoming the task of specialists, the results of their research, properly disseminated, attract wide public interest. In Canada, for example, one has only to look at the steadily increasing attendance records at museums and historic sites to appreciate that the past exerts a widespread fascination. The sense of history offers a continuity of identity in a rapidly changing world. It provides that perspective of time essential to a healthy national identity and to the recognition of the commonality of human experience on a world-wide basis.

The importance of understanding and preserving the past has been recognized, implicity or explicitly, by virtually every country in the world. This concern has been made manifest in the establishment

of archives and museums, in the commemoration of historic events and significant figures, in the preservation of historic places and objects, through the enactment of antiquities legislation and so on. While one cannot place a dollar value on the intellectual, emotional and aesthetic aspects of historical resources, it is clear that the wise exploitation of such resources generates considerable revenue. In 1961, the Government of Canada began the reconstruction of the 18th century French Fortress of Louisbourg. Already over a million people have visited the site and an annual visitation of up to half-a-million is anticipated once the reconstruction has been completed. It is expected that admission fees will produce a revenue of $400,000 annually with approximately $10 million being injected into the regional economy each year as a result of tourism. Over the same 10-year period, the annual visitation at all National Historic Parks has risen from 1,039,600 to 3,286,000.

While the development of historic resources requires the services of highly trained and highly paid specialists, it is surprising how often the impact of such work on the local labour supply has been overlooked. One of the planned benefits of the Louisbourg reconstruction was the provision of jobs in an area of high unemployment. The project generated over a thousand man-years of local employment (a $5 million payroll) in the first eight years of its existence, and is expected to provide 100 man-years of work annually until completion in 1976. Archaeological excavations, properly directed and controlled, can provide jobs for large numbers of unskilled labourers both in the field and in the laboratory. The Canadian Inventory of Historic Building, a survey of Canada's surviving architectural heritage, has been designed to be carried out by relatively untrained field recorders. Canada's system of national historic parks provides many summer jobs for university students as guides. Local labourers can be trained in many of the crafts required for reconstruction and restoration and this work can be used for the benefit of visitors; at Lower Fort Garry National Historic Park, for example, visitors flocked to see workmen hand-splitting shingles for use in the restoration. The development of historic resources can provide employment for unskilled labour (usually the first victims of unemployment) and can be used to teach these labourers new skills (e.g., brick-laying, stone-cutting). The work is non-competitive with industry and, hence, does not take away jobs from other areas. The result in the form of a developed historic site provides continuing employment in maintenance and interpretation, attracts tourists and, indirectly, as the Province of Ontario illustrated clearly in its Upper Canada Village operation, contributes to the creation of jobs in the services catering to these visitors.

3. EFFECTS OF MAN

Each year, an unknown portion of Canada's historic resources is destroyed by natural causes (e.g., erosion), but it seems highly probable that this is a very small fraction of the destruction caused by man himself. Unlike natural resources, historic resources are basically man-made, and their removal consequently represents the

destruction by man of his own handiwork. Like scenic or wilderness resources, they are vulnerable to depletion, but not as susceptible to authentic re-creation, for they derive much of their cultural interest and relevance, particularly in the case of building, from their status as the creation of human minds and hands. Age with concomitant decay, the natural propensity of society for change, and the sheer growth of human numbers, mean that historic sites are among the most prone of cultural values to loss. The construction of dams, reservoirs, highways and pipelines results in the obliteration of archaeological sites. Urban renewal and urban sprawl take an annual toll of Canada's surviving old buildings, and destroy or encroach seriously on the original surroundings that create an historical environment for the structures. Ancient shipwrecks are stripped of their contents for amusement or private gain, sometimes being damaged so extensively that their identification is impossible. The tragedy of the loss is, if anything, exacerbated by the fact that the precise magnitude of the destruction is unknown.

4. PRESENT PRESERVATION

In Canada, the responsibility (with certain exceptions) for the protection of archaeological sites, and historic sites of local significance, rests with the provincial governments. A number of these have enacted protective legislation while others have indicated an intention to do so. The chief problems seem to be a lack of funds devoted to enforcement, protection and the education of the public to the importance of these resources.

At the federal level, the National Museum of Man, working closely with provincial agencies and universities, carries out archaeological surveys and excavations of prehistoric sites dictated by both the need to fill gaps in current knowledge and the threat of destruction to sites in certain areas. This museum preserves in its collection objects of archaeological, ethnological and aesthetic significance while the National Museum of Science and Technology, as its name implies, protects those artifacts illustrative of scientific and technological developments in Canada. The Public Archives of Canada is responsible for the preservation of documents relating to Canada's past, while the National Gallery of Canada is custodian of many of the nation's art treasures. These institutions deal primarily with the collection and preservation of cultural objects and are not normally empowered to acquire and preserve actual sites. This is also generally true of the provincial, municipal and private agencies which perform similar functions although some of these have been housed in buildings of historic or architectural significance partly as a means of preserving those structures.

Several of the provinces have large and well-equipped museums which carry out important work in the collecting field, and hence salvage significant objects which might otherwise be lost to the Canadian public. The functions and powers of these museums, like those of the federal agencies cited above, do not usually extend to the acquisition and preservation of sites.

Provincial programs designed exclusively to preserve and develop historic sites, and operated by the provincial governments,

vary widely in scope and authority, depending largely on provincial priorities and regional economic problems. Most of the provinces have been marking programs under which sites of importance in provincial history are commemorated by plaques and monuments, with or without legislation to protect the sites thus marked from vandalism or prejudical transfers of ownership. Several have active preservation and development programs designed to save their most important sites and historic structures and make them available to the public, the emphasis to date being on the restoration of early buildings and the reconstruction of vanished features.

Federal responsibility for the acquisition, protection and development of sites of national historic significance is vested in the Minister of Indian Affairs and Northern Development, within whose portfolio fall the National Historic Sites Service and the National Parks Service. Although the last-named agency does not select its parks on the basis of historical considerations, the National Parks contain a considerable number of archaeological sites and a few sites with visible historic remains, and the National Parks Service (in collaboration with its sister agency, the National Historic Sites Service) has been active in carrying out surveys to determine the extent of the historic resources within its areas of responsibility. The objective has partly been to gather information for the interpretation of the human (in addition to natural) history of the parks for the benefit of visitors. Equally important, however, the data are required as a basis for planning development so that construction of roads or camping facilities will not inadvertently result in the destruction of historic sites.

The National Historic Sites Service, on the other hand, maintains sites that have been acquired specifically because of their importance in Canadian history and their development potential. National Historic sites are designated by the Minister of Indian Affairs and Northern Development on the recommendation of the Historic Sites and Monuments Board of Canada, an advisory group of eminent historians and archivists appointed regionally from across Canada. The recommendation of this Board is also taken under consideration when determining the type and extent of commemoration and preservation to be undertaken. Since sites are preserved for the benefit of all Canadians, some form of development is considered essential to permit persons of all age groups, educational backgrounds, etc. to appreciate the nature and significance of these historic places. An archaeologist, for example, may by able to discern the outlines of buried structures from the vegetation patterns in a field, but this would be of no meaning to the layman who lacks the requisite training. The necessary development may take the form of an on-site interpretation centre containing graphic exhibits and artifacts, interpretation signs, restoration and period refurnishing (in the case of standing structures), stabilization of archaeological remains and so forth. The objective of any form of development must be to preserve as much as possible of the original fabric. Reconstruction, though occasionally desirable, is a technique to be used very sparingly; funds devoted to this purpose are better employed preserving that which yet survives. Any site chosen must be genuine and any building must be in its original location.

Development proceeds only after extensive research. Prior to beginning work on any historic structure, extensive architectural drawings are made; these form a basic record against which future generations can check the accuracy of restoration or repairs. Work involving disturbance of the soil must be preceded by archaeological excavations. Authenticity and integrity must be the watchwords of historic development.

Parenthetically, it should be noted that both of the aforementioned Services are part of the National and Historic Parks Branch, an administrative arrangement which has worked to ensure that both natural and historic values are preserved in both park systems. As noted above, the National Parks Service is carrying out surveys of historic resources within its system for purposes of development planning and interpretation. Similarly, the National Historic Sites Service acts to preserve natural values associated with sites primarily of historic significance. The reconstruction of the Fortress of Louisbourg, for example, is being undertaken within a 27 square mile natural setting. Similarly, plans to develop the Chilkoot Trail and the Yukon Waterway (both parts of a long term program to interpret the Yukon Gold Rush) offer a striking opportunity to combine history with outstanding scenic attractions.

Since, in any country, the amount of money available for historic preservation is necessarily limited, it follows that these funds ought to be devoted to the most important and best possible sites and objects. In certain cases, such a decision presupposes the existence of an inventory of historic resources from which one can select the best. Faced with the problem of choosing the best surviving examples of Canadian architectural styles for commemoration, the National Historic Sites Service launched, in 1970, a program known as the Canadian Inventory of Historic Building (CIHB). The first step is to locate, through a survey of cities and rural areas, as many as possible of the country's surviving old (i.e., roughly pre-1900) buildings; it is estimated that about 100,000 of these structures will be recorded. From this number will be selected about 10,000 which seem to best exemplify architectural evolution in the country. More detailed analysis is expected to eliminate about 90% of this second group and from the remainder will be selected the structures for national commemoration. The Historic Sites and Monuments Board of Canada, which plays an important role in recommending priorities in the commemoration of Canadian historic sites, will be closely involved, as an advisory group, in the selection of the most important buildings.

The initial (phase 1) survey eschews the concept of architectural style; rather, it consists of a checklist of 78 categories relating to such features as chimneys, windows and roof line. Since phase 1 will yield some 7 million items of information, it has necessarily been programmed for computer processing. The results are expected to provide a much more accurate definition of styles than has hitherto been possible. More important, the checklist format permits the survey to be carried out by relatively untrained recorders instead of highly paid architects. These latter will be employed more usefully in evaluating the data, selecting buildings for further examination, and carrying out detailed studies in the later phases of the program.

The CIHB is more than a tool for the selection of a few structures to be commemorated as national monuments. The value to architectural historians of this immense body of statistical data needs no comment. Much more important is the potential for planners, civic administrators and citizen's groups concerned with the protection of the urban environment. Too often the characteristic North American response to the requirements for space necessitated by new aspirations and functions has been to tear down and rebuild rather than to adapt and modify. On financial and engineering grounds only, it may be cheaper and simpler to throw out the past. There is a rising resentment against an environment geared to fiscal and technological, rather than human consideration. Few buildings warrant preservation as museum pieces; many merit preservation as part of a viable, varied human habitat. The CIHB data provide a means of identifying both categories so as to permit planning for aesthetic as well as technological ends. While the categories selected represent Canadian architectural features, the system is believed to be applicable to any country.

5. FUTURE ACTION

5.1 GENERAL

A basic premise in dealing with the preservation of historic resources is that these belong to the citizens of Canada in trust for all people everywhere as a portion of humanity's cultural heritage. These resources must, therefore, be wisely exploited for the common good, not for private gain. By wise exploitation is meant the development of these resources so as to produce the maximum contribution to human knowledge coupled with the preservation, where possible, of tangible remains for the enjoyment and edification of future generations. The actual preservation of a site is not always feasible, nor necessarily desirable, but the acquisition of knowledge unquestionably is. Where sites cannot be preserved or must be destroyed for compelling reasons, the loss of the resource must be considered in estimating the costs and value of whatever project necessitates its destruction. As a principle, it is desirable that the user of common resources pay for the cost of this use.

Specific examples of desirable action are discussed as follows:

1. The continued implementation of the Canadian Inventory of Historic Building will expand and refine the accumulated data concerning Canada's architectural heritage.

2. Although a blanket survey of archaeological sites would be so difficult and expensive as to be unfeasible on a nation-wide scale, there should be a concentration of effort for survey and salvage in areas designated for major construction activity such as highways, pipelines, dams and river diversions. One approach might be to require that, on all

projects financed in whole or in part with federal funds, a portion of the federal contributions be earmarked for prior archaeology; in other words, to charge the cost of salvaging historical resources to the project which occasioned their loss. This, of course, could apply only to areas of central government involvement, but several provincial agencies have already adopted a similar approach and others might follow suit.

3. Another desirable approach would be to have all government agencies administering lands follow the example of the National Parks Service in its approach to archaeological survey and salvage on the lands under its jurisdiction.

4. With certain exceptions, jurisdiction over archaeological sites on land rest with the provincial governments and, as already noted, most have adopted some form of legislation. Consideration is being given to legislation protecting underwater sites in waters which come under the authority of the central government.

5. While the National Historic Sites Service can acquire structures and sites of national importance, it is not possible for all levels of government combined to preserve large numbers of historic places as museum pieces. Nor is this desirable, since history is a vital aspect of a living culture. Consideration is being given to the establishment of a national trust, to be called Heritage Canada, which would be able to explore preservation options not open to a government agency. In addition, Heritage Canada, in co-operation with the established provincial trusts, would serve as a channel for the involvement of private interests in the field of conservation.

6. Some thought is being given to the question of legislation restricting the export of antiquities. In that we share with all other nations a common interest in human culture, complete restriction is undesirable, but some measures may be necessary to stop large-scale export for private gain or the removal of particularly important pieces.

5.2 SUMMARY

While legislation may be the answer to particular problems, it is no panacea. No significant portion of any country's historic heritage can be saved if its citizens do not care enough to involve themselves. Through the CIHB program, private groups and individuals are becoming involved, on a volunteer basis, in the recording of Canada's architectural history. Historic sites, monuments and museums operated by all levels of government and by private concerns, seek the same end -- the stimulation of an awareness of national identity, of shared human culture, of concern to preserve and understand that which has made us what we are.

6. SYNOPSIS

1. Recognition of the cultural and economic value of Canada's historic resources has led to the establishment of museums, archives, commemorative monuments and markers, and increasingly to the preservation of historic structures and places by both federal and provincial agencies.

2. Rapid urban expansion and the remarkable growth of transport and power services in the past decade has increased the incidence of loss and poses a major, if yet unmeasured threat to the remainder of the resources.

3. As in other fields, there is an urgent need for planning, a reliable inventory of the resources, and adequate protective legislation. In Canada work is being concentrated in these areas to define the problem and develop surviving resources, but much remains to be done. Early architecture, the most obviously vulnerable of the country's historic assets is being recorded in inventories at both the provincial and federal level, with the latter giving high priority to a detailed national survey of building styles and surviving examples.

4. There is a clear need for legislation to protect archaeological sites and underwater sites, and it may be necessary to propose legislation placing some restrictions on the export of antiquities having an outstanding cultural relevance to Canadians.

5. In the last analysis an adequate solution to the problem of preserving historic resources in Canada can only be found in the value assigned by a people to the visible relics of their own evolution as a national society.

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Note - The paper contains no specific references to the above material.

THE CONSERVATION OF URBAN GREENBELTS WITH PARTICULAR REFERENCE TO THE NATIONAL CAPITAL OF CANADA

CONTENTS

THE CONSERVATION OF URBAN GREENBELTS WITH PARTICULAR REFERENCE TO THE NATIONAL CAPITAL OF CANADA

1. INTRODUCTION

The concept of maintaining a belt of open land surrounding an urban community can be traced from the 13th Century B.C. through the fifty-four cities of Sir Thomas More's Utopia (A.D. 1515-16), spaced twenty miles or so apart, to Ebenezer Howard's Garden City concept. In Great Britain belts of open land, called greenbelts, are conceived as rings of open land approximately 10-15 miles wide. The best known are those surrounding Birmingham and London. Within such greenbelts further development is not permitted and thus, the horizontal expansion of the communities into the countryside is stopped.

In North America, the unfortunate results of unrestricted development on the edges of built-up areas are all too familiar. Developers secure cheap land on the fringes and leave scattered vacant sites within the developed areas which if properly used, would accommodate substantial increases in population. As industries and shops relocate in new subcentres on the periphery of the urban communities, central business districts decline. Concurrently, the growth of ribbon and sporadic developments in the country requires costly infrastructures and the free flow of traffic on inter-urban highways is impeded, thereby spoiling the open countryside. For these ills, redevelopment and renewal plans have not provided the answer and the preservation of the countryside and the clean demarcation between town and country which has been one of the earmarks of English development, has not been equally successful in North America.

Because of the problems arising along the fringes of cities, since World War 11, many North American planners appear to be much attracted to the greenbelt concept. In the mid-fifties William Whyte wrote exhaustively on various concepts of land use controls and dealt with deed restrictions and the problem generated by such instruments. He suggested using open lands in North America as a means for controlling the configuration and development of a community. Later, it was considered that greenbelts in North America should be placed in a narrower land-conservation context. For example Santa Clara County, California used zoning powers to preserve land solely for agricultural purposes. Annexation by a municipality was then prohibited without the consent of its owners. Elsewhere the desire has been to purchase such open space but the costs are so great that funds have not been available for the task.

The National Capital Region in Canada, since World War II, has had all the typical 20th Century planning problems: rapidly growing population, intense building development, deficiencies in most urban amenities and infrastructure and, above all, too many automobiles to cope with adequately. While North American life and prosperity are based to a very large extent on the automobile, many problems arise from the

freedom of choice it gives on where to live. Because this freedom to move could have caused great problems in the future with the uncontrolled spread of the urban area, the Ottawa Greenbelt was conceived in the interest of preserving the natural environment and developing desirable patterns of urban development.

2. THE OTTAWA GREENBELT

The Ottawa Greenbelt is dealt with under the following headings:

- I Historical Background
- II Description
- III Purposes
- IV Land Uses
- V Comments
- VI Current Position

2.1 HISTORICAL BACKGROUND

Development of the Ottawa area, the National Capital of Canada, has been an active concern of the Canadian Government since 1899. The Plan for the National Capital, (1950) prepared by the late Mr. Jacques Greber on behalf of the Canadian Government contained many notable recommendations - one of which was the establishment of a belt of land approximately 4.02 kilometers (2½ miles) wide, called a greenbelt - a key, it was believed, to the achievement of a regional concept of land use. The belt was intended to circumscribe an area large enough to accommodate some 500,000 persons and its inner limit was determined by the area designated for the provision of economic municipal services.

The Plan for the National Capital, (1950) stressed National Capital and regional aspects of planning. Constitutionally, the Federal Government does not control land in the National Capital area except through ownership. Planning proposals, therefore, are generally achieved by liaison with the appropriate local municipality.

At the same time the Ottawa Planning Area board, which had limited jurisdiction over the Ontario portion of the Region, was concerned about the lack of an intergrated sewer and water system covering the 8 urban and suburban municipalities within its jurisdiction and authorized a comprehensive study. It was thought that a demarcation of limits for the extension of municipal services was necessary and that this could be done by implementing a greenbelt by land use controls such as zoning or an official land use plan - a provincial planning measure. However, the Townships of Nepean and Gloucester where the greenbelt was situated did not concur and accomplishment by zoning or land use appeared impossible. However, as the Ottawa Planning Area Board had to approve all development plans, it was able to delay building activity in the greenbelt pending action by the Provincial or Federal Governments. Nepean, Gloucester, the City of Ottawa and other jurisdictions were represented on the local Ottawa Planning Area Board.

The Federal Government continued its attempts to persuade

Townships of Nepean and Gloucester to create the greenbelt during the period 1948-1958, but the townships were unwilling to co-operate.

Practically all the arguments against the greenbelt, came from the township councils and from land owners and developers who would be affected. This matter was aggravated because for many years no decision had been taken to proceed with the project nor a method chosen by which it could be brought about. In 1955 the situation became quite acute as a ban was placed on mortgage loans in the originally proposed greenbelt area by Central Mortgage and Housing Corporation, a Federal Government mortgage lending institution, thereby indicating clearly the continued interest of the Canadian Government in setting up a greenbelt in the National Capital.

In 1956 a Joint Committee of the House of Commons and Senate was set up in order that the Federal Government could study the activities of the Federal District Commission, its agency charged with National Capital development. One of the prime functions of the Joint Committee was to investigate and report upon the greenbelt and to recommend either that it be proceeded with or that it be eliminated as a concept.

The evidence given before the Joint Committee made clear that, if the greenbelt was to be accomplished by zoning, compensation should not be paid for any financial loss. The Committee agreed with the principle that municipal zoning, "being for the good of the community" should not create a claim for compensation. About the same time this problem was dealt with by the Royal Commission of the Province of Alberta on the Metropolitan Development of Calgary and Edmonton, 1956, which considered that the best course for setting up a greenbelt was by outright purchase, but questioned its financial implications on the cities of Calgary and Edmonton. Therefore a recommendation was made in favour of zoning without compensation. (The Edmonton belt of agricultural land is basically a square of 32 kilometers (twenty miles) surrounding the square city having boundaries of 16 kilometers (ten miles). As a result of a strong Regional Planning Board and despite some encroachment, the City has been contained within these limits. Now, a limited amount of development is taking place on poor soils within the agricultural zone.)

The Joint Committee supported the validity of the greenbelt concept and urged that further steps be taken with provincial and municipal authorities to find a workable arrangement for implementation before proceeding with acquisition by purchase or expropriation. This involved trying to resolve the conflict between national capital 'core' interests and the interests of the 'outlying' municipalities, both of which operated without any agreement on a regional land use plan. All steps proved fruitless and after several years, it was evident that if there was to be a greenbelt, the land would have to be acquired by the Federal Government. Accordingly, in 1958 the Canadian Government, after more than ten years of endeavour and the exhaustion of all other possibilities, decided to acquire all those parts of the greenbelt not in public ownership.

At that time, the purposes of the greenbelt were described as:

I To prevent further haphazard urban sprawl around the Capital, including ribbon development along approach highways, and so to protect adjacent farming areas from being swallowed up by uncontrolled development;

II To meet long term National Capital planning needs by ensuring that when the central area was built up, an adequate reserve of sites for future buildings, for government and public institutional purposes, was retained;

III To place a practical and economic limit on the growth of the capital by confining intensive building development to an area which could be provided with municipal services at a reasonable cost.

The method of acquiring land was by purchase, or if necessary, by expropriation. In the latter case it was thought that land costs could be fairly established through test cases heard by the Exchequer Court of Canada, a senior Canadian Court.

The suggested permitted land uses were:

I Existing farm market gardens and woodlots;
II New and existing federal uses;
III Approved public developments on more than 5 acres with ample clearances with respect to all boundaries;
IV Park developments of an unsophisticated character;
V Private industry on land of 10 acres or more in extent;
VI Highway and railway rights-of-way;
VII Residential uses in the future, provided that such were on property of more than 2.23 hectares (5½ acres). (While this use may have been desirable, lack of schools and other amenities would have limited the amount of such development.)

Greenbelt lands were in no way 'sterilized' or otherwise taken out of permitted uses. Most of the land was to be leased to former owners or tenants who wished to farm or carry on similar activities.

The foregoing applied to the greenbelt area in Ontario. As development had been slower in the Quebec portion of the National Capital Region, the situation was not considered critical. The Government already had substantial holdings through property acquisitions in Gatineau Park comprising, now, about 28,329 hectares (70,000 acres) lying along the high ground between the Ottawa and Gatineau River valleys. Nevertheless, very tentative plans were considered for the acquisition of the properties necessary for a greenbelt in Quebec. Later, studies confirmed that the shape of the ground did not warrant a belt of land in public ownership. Instead Gatineau Park and similar wedges extending radially from the urban core would be more suitable.

In effect, the Ottawa Greenbelt can be viewed from two equally valid points of view:

I As a long term planning measure to contain an urban area and provide open space for future generations, and

II as a location for a variety of open space uses.

2.2 DESCRIPTION OF THE OTTAWA GREENBELT

The greenbelt can be visualized as forming the outer part of half of a saucer with the urban core situated in the bottom and with its edge being interrupted in several locations. A ridge of high ground extends in an arc from the Ottawa River in Nepean Township to this River in Gloucester Township. In part of Gloucester Township a large peat bog, Mer Bleue, extends westerly into the greenbelt with three fingerlike parallel ridges rising 7.6 to 12.2 meters (25 to 40 feet) above the level of the bog. North of the Mer Bleue the terrain rises to 114 meters (375 feet) above Mean Sea Level and then drops abruptly to an elevation of 53 meters (175 feet) near the Ottawa River.

Areas of poor drainage are scattered throughout the greenbelt. In Gloucester Township, Green's Creek is the principle drainage course, while in Nepean Township, Watt's and Still Water Creeks drain into the Ottawa River and Black Rapids Creek empties into the Rideau River.

Soils within the greenbelt are composed mainly of clay and sand but imperfect drainage and lack of depth to bedrock have caused large areas of poor quality soil. The bedrock underlying the greenbelt is mainly Ordovician limestone with minor sandstone and shale, and Precambrian gneisses.

The natural vegetation of the greenbelt comprises a mixed forest of hardwoods and conifers. The principle wooded area is in the western part of Nepean Township where the main species are elm, ash, pine and, in the poorly drained areas, cedar.

2.3 PURPOSES

The urgency with which the Federal Government viewed the greenbelt problem arose very largely from studies of population growth. In 1955, the population of Ottawa was 220,000; and that of the Ottawa-Hull metropolitan area 325,000. By 1980, it was estimated that the population of the metropolitan area would be 600,000 but today (1971), this figure has already been exceeded. The population is expected to increase by about 50% in the next 25 years. Where this increasing population will live and work is of concern to all levels of government involved in planning within the National Capital Region.

Establishment of the greenbelt is not intended to, and in fact does not, restrict the population growth of the capital area. Growth beyond that for which economical provision can be made in the Ottawa-Hull metropolitan area is to be met by independent and self-servicing satellite communities of up to 100,000 population, located beyond the outer limits of the greenbelt. The nucleus for a number of these communities already exists and the establishment of more, as required, will be encouraged.

The greenbelt was set up to control ribbon development and urban sprawl within its boundaries and has done so. This is a problem common to most Canadian municipalities, as the Housing and Social Capital section of The Report of the Royal Commission on Canada's Economic Prospects, (1963) indicated: "The built-up area will generally be found to straggle on along a few well-maintained provincial highways...Aesthetic considerations apart, such ribbon development has two important disadvantages. The first is that it is extremely expensive to provide with sewer and water services, if indeed, it is provided with them at all.... A second disadvantage is that it ruins good highways.... Ribbon development is not the only uneconomic kind of urban sprawl. Sometimes there is a sort of leap-frogging; blobs of housing appear, not on the edge of the existing built-up area, but some distance away - perhaps in a hitherto rural municipality." "Various answers have been suggested to these questions. One frequently varied proposal .... that a geographical limit be set to the expansion of large urban areas: that this boundary be girdled by a greenbelt in which only what are known as low density land uses would be permitted, and that further growth be channelled into properly serviced and relatively self-contained satellite communities."

The greenbelt provides a reserve of sites for buildings and uses of the Federal Government. In fact, when the greenbelt was aquired there were already 2497 hectares (6,170 acres) of federally-owned land devoted to a variety of uses. Today, a further 1619 hectares (4,000 acres) are being used by an Experimental Farm, and 890 hectares (2,200 acres) by the Department of National Defence, along with substantial areas used by a variety of similar Federal purposes.

One function of the greenbelt is to protect the agricultural activities carried on in those areas where the nature of the soil made these economic. It is necessary to protect land for market gardens and for general farm purposes, mainly dairying because lands for these purposes were in limited supply near the National Capital, and farm lands adjacent to the urban core represent an amenity which could be quickly destroyed by sporadic development.

Creation of the greenbelt did not cause any immediate shortage of lots for home building purposes within the City of Ottawa or in either of the two adjoining townships of Nepean and Gloucester. At the time the decision was made to acquire the greenbelt, three times as many building lots were available each year within the City itself as were required to accommodate one year's requirements. Also, about 3,600 building lots were available on approved plans of subdivision in the two townships to meet an annual demand of only 500.

2.4 LAND USE

With the exception of land used for highway purposes, no land within the greenbelt may be transferred out of Federal Government ownership. The use of land by others than the Federal Government or its agencies is carried out on a lease basis for terms as long as 60 years. Uses which are permitted in the greenbelt are;

I. Federal, provincial and municipal uses, particularly research establishments, public utilities, sewage and water treatment plants, hospitals, religious and charitable institutions, educational establishments.

II. Reforestation and forestry, incidential logging operations, wildlife preserve, conservation activities.

III. All recreational uses such as public parks, playfield playgrounds, golf courses. driving ranges, archery ranges, gun clubs, athletic fields, community halls, open or enclosed swimming pools or bathing areas, botanical and zoological gardens, skating rinks, bowling greens, tennis courts, arenas, curling rinks, marinas, camping sites and trailer parks.

IV, Scientific and industrial research and development laboratories, plant facilities associated with laboratories and offices. These activities frequently require sites protected from fumes, smoke and electronic interference or contamination from other uses found in a metropolitan area.

V. Rock quarrying, rock, sand and gravel pits and gravel crushing.

VI. Orchards, field crops, flower and market gardening, poultry, dairying. pasturing, animal husbandry and nurseries.

VII. Refreshment pavilions or booths as accessory uses to recreational uses.

Because the quantity of land devoted to each use has been modified substantially since the greenbelt was acquired, the changes in the use of land during the past eight years is of interest. These occured because the Federal Government and public requirements have changed and because of soil surveys.

The following table indicates areas of land uses in 1961 and 1969 and forecasts probable future uses.

TABLE I - LAND USE IN THE OTTAWA GREENBELT, 1961 AND 1969. (a)

Land Use Category	1961		1969		Target Figures	
	Hectares	Acres	Hectares	Acres	Hectares	Acres
Agriculture						
Farms	10,443	25,800	6,026	14,890	4,010	9,909
Market Gardens	404.7	1,000	132	325	437	1,081
Government						
Airport	1,354	3,346	1,354	3,346	1,354	3,346
Research	1,155	2,854	3,153	7,790	3,853	9,159
Reforestation Woodland and Conservation	2,873	7,100	4,776	11,801	3,934	9,720
Recreation	129.3	320	210	522	1,286	3,178
Commercial and Industrial	206	510	75	185	969	2,395
Institutional (such as hospital	-	-	13	33	278	686
Transportation Corridors	-	-	189	466(b)	361	893
Nurseries NCC, City of Ottawa	-	-	49	121	49	121
Quarries	125	310	154	380	125	310
City Dump	-	-	42	104	-	-
Vacant/Idle (pending change of use)	-	-	517	1,277	-	-
Miscellaneous	-	-	-	-	33	82
Total	16,690	41,240	16,690	41,240	16,690	41,240

Note: (a) In part, changes reflect a greater degree of refinement in definition of uses.

(b) Land used for roads is not included in total.

At the time of the greenbelt acquisition although approximately 10,441 hectares (25,800 acres) were in use as farming, many of these farms were uneconomic - mainly because of size and soil conditions. However, two or three tracts of land were worth preserving for their agricultural capability and an attempt has been made to consolidate them into economically viable farms. Those carrying out market gardening, an important use in the community, have been encouraged to remain although now this use has decreased to 131.5 hectares (325 acres). This decrease occurred because of the short growing season and the labour intensive nature of market gardening which encouraged the gardeners to leave when they were paid for their land. The remaining farm lands either have been reforested or have been turned over to other uses such as research centres.

2.5 COMMENTS

The Ottawa Greenbelt has been rather controversial since its inception not so much as to the concept, but to its development and administration. Many of the comments made about it have been reasonably valid although not always based on full data. Accordingly, some of the more important comments and explanations are set out below.

(a) The Basic Concept

Some authorities have been using greenbelts as permanently restrictive of urban growth. Abercrombie's Greater London Plan delineated a greenbelt in this role to aid the national policy of urban decentralization and dispersal. On the other hand, Raymond Unwin thought that greenbelts should be used as a temporary restriction on the development of the urban fringe, thereby encouraging orderly expansion of a community from the periphery outwards. Whether permanent or temporary, a greenbelt is an attempt, by the exercise of public powers, to withhold large areas along the urban fringe from development and is thus a control on the physical growth of the community. But, because the restrictive function of a greenbelt is not considered by some to be consistent with the dynamic nature of a metropolis, the concept is frequently subject to criticism. Quotations which follow give the sense of this criticism:

> "... that the growth of the metropolis should be limited by a greenbelt goes counter to the dynamic nature of the metropolis. It is doubtful that its expansion could or should be stopped. but it should be possible to channel and organize it."(1)

> "... Greenbelts are instruments primarily of restriction. Moreover, it is the essense of greenbelt policy that the restriction should be permanent. But permanent restriction sits uneasily with the knowledge that steady population increase is likely (in the London area) for as long as anyone can foresee." (2)

On the other hand, Dr. Alice Coleman has this to say: "The agreement for recentralization is an example of how difficult it is for a city to adopt advanced planning policies, even when the opportunity exists to do so. Ottawa is still small enough for the advantages of growth to be apparent while the disadvantages remain merely incipient and hence attract no pressure of opinion to control them. In spite of this lack of pressure, the planners can forecast the future, and can take action now to avoid them by multicellular planning for example, then the city can be spared the normal range of costly growing pains.

It is greatly to the credit of the ... National Capital Commission that their urban planners have exercised a great deal of enlightened guidance in advance of need. The establishment of the greenbelt is a major example of this, and its effect upon the spatial organization of the city appears to have been in precisely the hoped for direction." (3)

(b) As a control of sprawl

When the Federal Government acquired the Ottawa Greenbelt no effective regulation of land use in the rural fringe adjacent to the urban areas was being exercised by the municipalities. Thus, controls did not exist to prevent sprawl and considerable land was being used for the building of a low standard type of housing in isolated locations. Most of these areas were beyond the reach of urban services, such as sewerage, water, police and fire protection, hospitals, schools, etc. A general criticism is made however, from time to time, that the greenbelt merely moves slums from the inner area to the outer limits, and that no real change is brought about, merely a locational shift.

Sprawl, being low quality housing in rural areas adjacent to cities, is a product of differential land values. In a country like Canada where land transactions are carried out under free market conditions, substantial numbers of less affluent persons searching for the single family home are obliged to move beyond the outer limits of the city. Land there is cheaper because municipal regulations governing development are more relaxed than in the urban centre. (Costs of transportation are generally discounted).

Dr. Coleman considers that there is a gap in rural planning between urban planning and conservation and that three fundamentally stable and desirable territories exist, Townscape, Farmscape and Wildscape. Between the first two territories, an unstable and undesirable zone lies which she refers to as the 'rurban fringe' and another equally unstable and undesirable zone, the 'twilight fringe' is contained between the Farmscape and Wildscape. Both undesirable zones are found in the Ottawa area and are characterized by extensive areas of idle land which she considers should be planned out of existence as these 'fringe' zones create a wide range of social and economic problems. Unfortunately these problems are compounded by the existence of numerous local authorities, who are unable to see

beyond their local and immediate needs to the wider common good. Dr. Coleman concludes that this fractional thinking, while understandable, impedes progress and reinforces the need for a regional government that would control a large enough area to be able to plan without the barrier of administrative boundaries.

Based on the Ottawa experience strong regional planning is required as well as a greenbelt to prevent urban sprawl.

The need for better regional government advocated by Dr. Coleman and nowadays regional governments operate in both the Ottawa and Quebec portions of the National Capital. Whether they will or can introduce the controls recommended by Dr. Coleman and eliminate all the 'fringe' area problems remains to be seen. Certainly such steps should be tried.

The Ottawa Greenbelt which surrounds the urbanized area is not regarded as a restrictive measure but as a farsighted step to preserve open land for future generations. At the same time, it will assist in the development of the National Capital Region so that Canada's Capital will become an exemplar for urban development. Thus, the Ottawa Greenbelt is analogous to the Abercrombie concept in that when the population exceeds capacity at the urban centre, overspill will be accommodated into satellite cities.

(c) As a Protection for Farms

The greenbelt is frequently cited as a device for protecting agricultural lands and this has been an objective of the Ottawa Greenbelt. That much farmland is still being worked indicates that this has been successful but, only after the uneconomic lands existing when the greenbelt was acquired had been put to other uses. In the recent study by Dr. Coleman, the Government was criticized for considering the maintenance of farms on the agricultural lands it acquired as being secondary to its reforestation programme. While some preference has been given to reforestation over agriculture, this occurred, in part, because many farms being worked on marginal soils were uneconomic and had to be eliminated. Of the many options available, reforestation was adopted as the cheapest "holding activity" of those having long term advantages. It was realized that in 30-40 years time, the mature trees on reforested lands would play an important open space/recreation role in the expanded urban community.

2.6 CURRENT POSITION

The Canadian Government does not have responsibility over land use because constitutionally this right has been vested with the provinces. The Province of Ontario has recognized the need for overall regional development and has created a Regional Government which includes the City of Ottawa and the surrounding municipalities. As a result more efficient social and economic programs are expected. Regional Government

has been given wide powers to control infractructure, transportation and planning from which more effective land use controls may flow. Accordingly, it is expected that the lands beyond the greenbelt will achieve their full potential as employment centres and residential areas while the greenbelt will become still more important as open space and as a land bank for Federal Government and public needs.

3. FUTURE ACTION NEEDED

1. Where growing communities exist governments should establish open space under public control to preserve land for future public needs; to contain and direct the growth of urban communities, and to provide recreation areas.

2. To control sporadic development in outlying areas strong regional planning control is essential.

3. Within urban communities ample open space should be provided to offset any increase in building density brought about by containment of a community.

4. The location of institutional buildings should be such that they form anchor points within the core matrix about which other forms of development may occur.

5. Attention should be focused upon the relationship between buildings so as to create a better urban environment.

4. SYNOPSIS

1. The concept of containing an urban community by an inviolable belt of open land is an ancient one. It guides horizontal urban growth; curbs uneconomic sprawl and provides a framework about which reasonable development of central city and satellite community can take place.

2. In Ottawa topography was one of a number of important considerations which led to a decision to develop a belt of open land in the southern half of the region. In the northern half, where the plains give rise to foothills, it was considered sufficient to develop green finger-like wedges such as Gatineau Park. Some of the other factors were local political considerations, the existence of large tracts of land already in public ownership, and the extent of the water-table.

3. Without some form of public control of land around communities, (whether by public ownership or by special legislation) in our society these communities expand in a disorganized and costly horizontal manner, usually beyond the financial capacity of the community to adequately service. In Ottawa, the greenbelt is in public ownership.

4. Containing a community by a greenbelt almost automatically implies an increase in density. As a result a sensitive relationship of size and density of buildings to open space is considered essential. Ottawa has chosen to achieve open space by developing landscaped parkways, large parks and recreational areas. The greenbelt is being reserved for future public needs.

5. Management of open space areas requires careful consideration, especially at fringe areas such as those which occur at both boundaries of the greenbelt.

6. Because of population growth and many people wishing to live in single family detached houses (a tradition in Canada), satellite communities have been established. There is some concern that these may develop only as dormitory towns.

7. Additional to the greenbelt, which is only one of a number of planning measures to ensure proper orderly development of a community and its hinterland, a strong regional type of government would assist in preventing sporadic development which inheres against the countryside.

8. In years to come, when urban communities are built on both sides of its boundaries, the greenbelt will become invaluable open space. It is a farsighted project, as the land was acquired while values were changing from a rural to urban base. Today, because of the increase in land values, it would not be financially feasible to provide a greenbelt so close to the centre of Ottawa.

The greenbelt has had a major effect on the core of the National Capital where a needed increase in building density has resulted from the limitation of urban spread. At the time of the acquisition of the greenbelt major construction programmes of high-rise office and apartment buildings were started by developers. This, plus the protection of farmland, the provision of sites for future Federal research activities, the control of sprawl and the reduction in substandard rural housing justifies the Ottawa Greenbelt and perhaps suggests the use of a similar device elsewhere.

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THE NATIONAL CAPITAL REGION
LA RÉGION de la CAPITALE NATIONALE
GLOUCESTER TOWNSHIP
NEPEAN TOWNSHIP
LEGEND
The National Capital Region
Greenbelt Gatineau Park
Built-up Area
Road Under Construction or Proposed
LÉGENDE
La Région de la Capitale nationale
Ceinture de Verdure Parc de la Gatineau
Superficie construite
Route projetée ou en voie de construction

PROBLEMS IN CANADIAN CONSERVATION LAW

CONTENTS

PROBLEMS IN CANADIAN CONSERVATION LAW

1. INTRODUCTION

The legal system of a nation establishes the basis framework within which conservation problems must be considered and initiatives undertaken. For example, the nature of legally recognized private land tenures, and basic statutory guidelines and policies for public land administration, have extensive implications for the success of virtually any conservation measure or program. Laws governing expropriation, and more generally, laws regulating various types of extractive resource development raise even more obvious legal problems related to conservation.

Conservation activities in Canada generally do not fit well within the existing legal framework. The basic reason is that Canada is a developing nation, still heavily dependent upon primary resource industries and therefore her laws relating to natural resources and public property remain strongly development oriented. As a result, natural and unintensive use areas are often extremely vulnerable, unless legal and administrative protection is provided. Too often conservationists and scientists are not sufficiently aware of these basic legal problems.

An example of the manner in which these problems arise is the experience in 1969 of scientists involved in the Matador Grassland Project in Southern Saskatchewan. They discovered that an oil company held petroleum and natural gas permits over the grassland research area that legally entitled the company to enter and commence drilling operations at any time. The entire research program was thereby rendered subject to disruption and even termination.

This paper will examine legal problems in Canada relating to two general conservation objectives. The objectives are:

I Preservation of species, habitats and sites for specific purposes (e.g. ecological reserves); and

II Protection and management of referent areas for a range of socially beneficial and relatively unintensive uses (e.g. wilderness recreation areas).

Various legal and administrative techniques will be considered as means of moving toward the objectives stated. Because of fundamental tenurial and regulatory differences, private and public lands will be considered separately. Extensive reference will be made to two documents (1, 2). The former is a paper entitled "Legal Techniques for Pollution Control: the Role of the Public", presented to the Eighth International Comparative Law Symposium in Ottawa, August 27th, 1970 and revised for publication shortly in the U.B.C. Law Review. The paper deals essentially with legal problems in pollution control administration. However, since physical environmental damage is clearly one of the major dangers to which referent areas will be subjected, most of the discussion related to the effectiveness of various legal and administrative pollution control techniques is equally relevant for the purposes of this paper.

A project group at the U.B.C. Law Faculty has formulated a proposal for an Ecological Reserves statute in British Columbia (2). This document outlines a series of legal problems related to objective (1) above, and proposes model statutory provisions designed to approach this objective within the constraints imposed by the British Columbia legislative and administrative systems. It is likely that similar problems would be encountered in other provinces.

2. LEGAL TECHNIQUES

2.1 PRIVATE LANDS

It is possible for private individuals to dedicate land held by them for the purpose of preserving or protecting species, habitats and sites. This will involve using an appropriate type of tenure or other legal holding mechanism to ensure that the lands continue to be used for the designated purposes following a transfer or death of the donor. Grants or demises of determinable fee simple interests[1] and trusts[2] subject to appropriate conditions regarding preservation and management, are devices that may be used. The holding entity under either of the devices mentioned might be a corporate structure established solely to acquire and manage lands for particular conservation purposes (such as the Nature Conservancy), or possibly even a government agency or department. Alternatively, a re-grant or declaration or trust could leave the donor himself in possession, but subject to the protective conditions of the grant or trust. It might also be possible to achieve the preservation objective by encouraging private owners to grant other limited interests, such as easements[3] or restrictive covenants,[4] to public or private conservation agencies.

2.1.1 Private Civil Actions. Where privately held areas are sought to be preserved for specific purposes or subjected to management for unintensive uses, protection may be obtained through private civil actions in the courts (1, at p. 2-3). Use of neighbouring lands in any manner that causes physical damage to the referent area (e.g. by pollution) may be enjoined in actions based upon a number of well-recognized heads of tort and property liability. Similarly where no physical damage is caused, but the use of the land is substantially interfered with, the offending land use may also be enjoined.[5]

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[1] E.g., To X and his heirs so long as the land is used for ecological research purposes: See generally Megarry and Wade, The Law of Real Property 75 (3'd ed., 1966).

[2] Id., ch.8.

[3] Id., at 802-818. It may be necessary to create statutory easements appropriate for conservation purposes since recognized classes of easements are limited.

[4] Id., at 753-772.

[5] E.g., where use of an island marsh as a wild fowl preserve is harmed by pollutants discharged into the river by an upstream industrial plant.

However, in this latter case the court will consider the nature of the locality and the types of land use that are and have been common, with a view to determining whether on balance the use complained of is "unreasonable". It can be seen that to the extent that considerations of purely economic benefit weigh heavily in this determination, legal protection for referent areas subjected to use interference but not physically damaged may be somewhat tenuous. Several other important limitations on the effectiveness of private civil actions as protection techniques are outlined in the above mentioned proposal for an Ecological Resources Statute in British Columbia (1, at p. 3-5).

2.1.2 Criminal Sanctions. Criminal sanctions in various Federal and provincial statutes may also be used to protect private as well as public areas. Examples include legislation relating to petty trespass, wildlife and plant protection, and statutes restricting or prohibiting waste discharge into water, land or air, all backed by minor criminal sanctions in the form of fines and/or imprisonment. Problems with this means of protection however are frequent lack of enforcement, and the questionable deterrents provided by the minor penalties specified upon conviction (1, at p. 5-6).

2.1.3 Expropriation. Privately held areas are subject to expropriation in whole or in part by a variety of public, quasi-public and private agencies for a wide range of uses. Very often under the expropriation statute neither the necessity of the taking nor the area to be taken can be effectively disputed by the owner;[6] though he will normally be entitled to adequate compensation. It is possible of course to specifically exclude certain natural areas, or special use areas from the operation of expropriation powers,[7] but this has rarely been done. Also, public hearing requirements by which the public interest and necessity of the taking may be questioned could, through the publicity and public reaction generated, serve as a type of indirect protective mechanism (1, at p. 11-12).

2.2 PUBLIC LANDS

Like private natural areas or unintensive use zones, similarly managed public lands require protection from conflicting extractive uses such as large scale logging and mining operations (2, at p. 6-7). This must be done by legislation that provides machinery for designation of such areas, lays down selection and management criteria, and specifically excludes designated areas from the operation of laws governing extractive resource use and development (2).

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[6] See e.g., Dome Petroleum Limited v. Swan Swanson Holdings Ltd., (1971) 2 W.W.R. 506 (Alta. C.A.).

[7] See E.G., The University Act, S.B.C. 1963, c. 52, s. 39.

2.2.1 Entrenchment. Of vital importance is the specific method of establishing, adding to, and especially subtracting from or altering protected areas. Provision for establishment, and alteration or disestablishment by simple order-in-council renders a protected area subject to reclassification by an order that requires no advance notice of the change. This is particularly true where abolition or reclassification is by ministerial order alone, as opposed to cabinet order-in-council. Again, a prior public hearing requirement may provide an effective indirect check on inappropriate exercise to these powers. Another method of entrenching areas might be to require an act of the legislature to disestablish or alter any designated area, thus guaranteeing advance public notice and debate through the legislative process. For convenience and expedition in carrying out the program, protected areas could continue to be established by order-in-council. Still another possible structure involves formal establishment of an expert advisory committee, with a majority of members from outside the civil service that must be consulted before any reclassification order is made (2, at p. 4-5).

2.2.2. Agency Co-ordination. Total preservation in perpetuity of natural areas and protection from all destructive uses may be most desirable; or even ecologically unsound use of certain natural areas in situations of compelling public interest. This flexibility can be built into a public conservation program provided adequate procedural safeguards are established. Mandatory public hearings prior to withdrawal decisions have already been suggested as protective devices.

Another safeguard may take the form of appropriately structured and co-ordinated administering agencies and government departments. Resource management and use legislation has traditionally been established on a single basis, with separate legislation and administrative structures for forests, minerals, water etc. The various resource agencies created have often pursued separate policies and procedures with little attempt to co-ordinate on a total resource basis. One of the results is that a kind of pre-emption of public lands for extractive resource development becomes possible. This occurs when, for example, interests are acquired by locating claims under mineral legislation and exploration work discloses substantial mineralization. Approvals may then be obtained from the relevant mines department and substantial sums of money invested in development operations. Lack of departmental co-operation and co-ordination may result in protection agencies such as pollution control and natural area authorities being consulted only at this point. The substantial investment and extractive resource agency approvals already obtained practically guarantee that the development will proceed. The only question becomes what requirements can be imposed to minimize damage to protected areas (1, at p. 10-11).

A slightly different problem arises where administration of natural or protected areas is entrusted to an agency within a government department that is also responsible for extractive resource development. If, for example, the responsible minister is charged with Forest management and use, on the one hand and natural area protection

on the other, he may be placed in a delicate position that is analogous to a conflict of interest. In this situation, the protection function usually suffers (1 at p. 4 and 14). This problem can be alleviated by creation of separate Conservation or Environment departments with ministers responsible solely for environmental protection and renewable resource management. An example of a move in this direction is the proposed Federal Environment Department.[8]

3. PUBLIC PARTICIPATION

Conservation agencies could often benefit from expertise located outside the civil service - in universities and in industry for example. Formally constituted advisory groups consisting of persons with technical and scientific competence could be established to advise public administrators in carrying out the aims and purposes of conservation legislation. This public input may also serve a protective function by bringing agency decisions regarding designation, management and abolition into public view. This would be particularly true where such advisory groups are empowered to hold public hearings on matters affecting protected areas. The necessity for this public participation in certain conservation agency decisions, especially those concerning conflicting resource uses, is elaborated elsewhere (1, at p. 11-13). It is also suggested there that protection might be enhanced by legislation allowing private individuals not themselves affected in a direct economic sense, to bring legal actions either directly against persons causing environmental damage; or against the enforcement agency to compel it to act if it fails to do so. The effect is to constitute concerned individuals "private attorney-general" with status to commence legal action to enjoin damage to publically-held protected areas.

4. SYNOPSIS

This very brief outline of some of the legal and institutional problems related to conservation objectives is intended to emphasize two main points. First, it is clear that the overall legal structure, and particularly the institutional and tenurial arrangements for holding and managing protected areas, whether public or private, are of considerable importance. Generally, the Canadian legal system has a development orientation and does not readily accommodate protected natural areas and unintensive use of zones such as wilderness areas. As a result special legal and administrative protective measures may be necessary. In particular efforts must be made to ensure that procedural safeguards are established to prevent removal of protected status except for clearly established reasons of compelling public interest.

Second, an important means of safeguarding protected areas involves the interest, concern and expertise of members of the public.

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[8] Government Organization Bill, No. C-207, 1970.

It has been suggested that public hearing requirements on reclassification and abolition decisions can be used to bring pressure on administrators by demonstrating that a status change is not in fact in the public interest. It has also been suggested that expertise in designation and management of protected areas can be provided by advisory committees including scientifically and technically qualified persons from outside the administering public agency.

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APPENDICES

I - III

APPENDIX I

SITE SURVEY AND RESERVATION RECOMMENDATION BY THE IBP/CT SUBCOMMITTEE IN CANADA

The International Biological Program (IBP) has an active Canadian Committee (CCIBP), and under its aegis several programs are being carried out in Canada; the aim is to investigate the biological basis of productivity and human welfare. IBP studies are in progress on grasslands, tundra, taiga, lake and marine biomes and human affairs in Canada, as well as research in soil microorganisms, photosynthesis and nitrogen fixation. IBP also supports studies of environmental law.

A Subcommittee on Conservation of Terrestrial Communities (IBP/CT) was organized in 1965 and is concerned with surveys of sites suitable for reservation. This subcommittee is mainly concerned with preservation for scientific purposes and to ensure a scientific foundation for conservation (1). The IBP/CT subcommittee has carried out a survey (2) of many Canadian sites (Figure 1) using standard check sheets (3). For the purposes of the survey Canada has been divided into ten regions (British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, Maritimes, Newfoundland, Tundra, Taiga). Candidate areas have been proposed for inclusion in a network of ecological reserves (Figure 2) and some areas already have reserve status (Figure 3). The IBP areas with conservation status are concentrated in only four of the regions so far (Ontario, British Columbia, Alberta and Saskatchewan). In the case of the first three of these there are official governmental groups working with the IBP/CT subcommittee (2).

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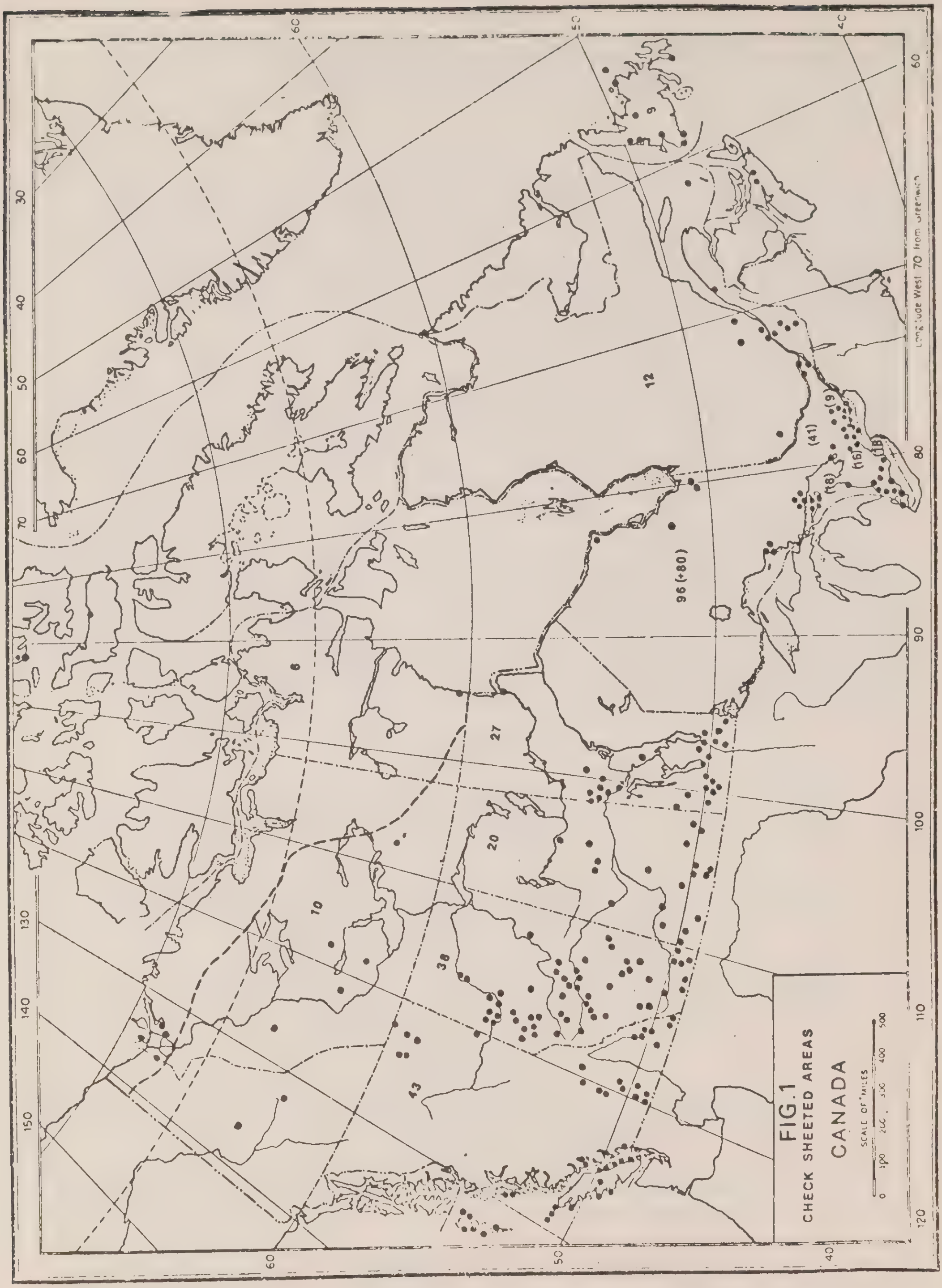

FIG.1
CHECK SHEETED AREAS
CANADA

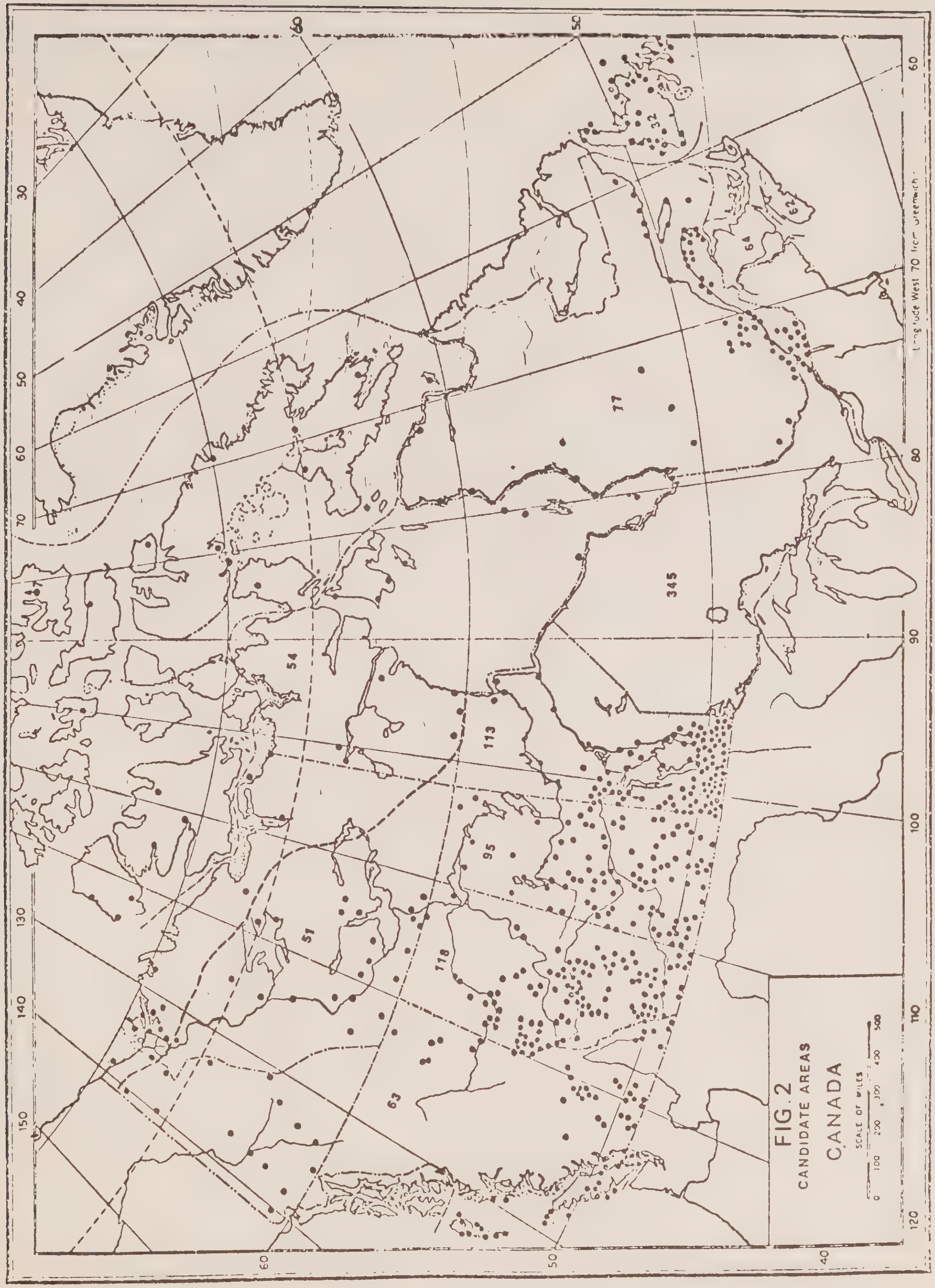

FIG. 2
CANDIDATE AREAS
CANADA

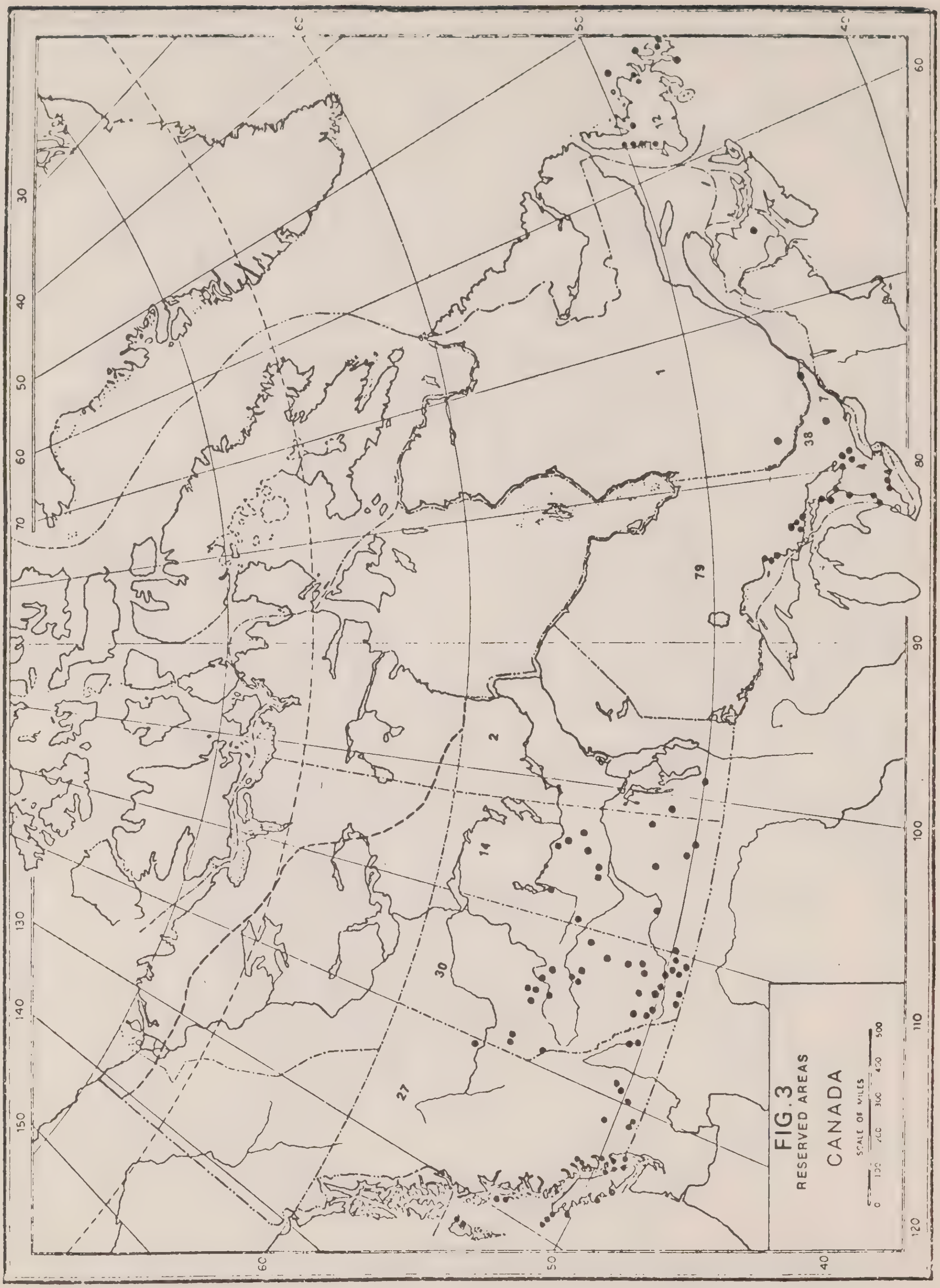

FIG. 3
RESERVED AREAS
CANADA

APPENDIX II

NATIONAL & PROVINCIAL PARKS IN CANADA

The following table summarizes the numbers, areas and classes of National and Provincial Parks in Canada, based on information provided by the Federal-Provincial Parks Conference. The two tier classification used is the system established by the Federal-Provincial Parks Conference of 1963, and is based on seven (A-G) classes distinguishing the nature and purposes of areas, and three (1-3) degrees of protection. In fact the classification systems used vary from one province to another, and the National Parks differ in their classification from any provincial system. The system used in this report was adopted for sake of uniformity.

Additional parks are being created to meet a growing demand for such areas.

	Class of Park	Natural and Historic Parks			Provincial Parks			Total		
		No.	Area hectares	Area acres	No.	Area hectares	Area acres	No.	Area hectares	Area acres
A_1	Wilderness Areas, fully protected	13	3,115,551	7,698,420	14	4,249,714	10,500,900	27	7,365,265	18,199,320
A_2	Wilderness Areas, primarily for outdoor recreation, some exploitation	1	4,480,838	11,072,000	8	8,100,534	20,016,146	9	12,581,372	31,088,146
A_3	Wilderness Area, multiple use	0	0	0	21	7,125,383	17,606,580	21	7,125,383	17,606,580
A	Total Wilderness Areas	14	7,596,389	18,770,420	43	19,475,631	48,123,626	57	27,072,020	66,894,046
B_1	Historical, etc., full protected	49	6,317	15,609	198	3,777	9,332	247	10,094	24,941
B_2	Historical, etc., primarily for outdoor recreation, some exploitation	0	0	0	4	1,921	4,747	4	1,921	4,747
B_3	Historical, etc., multiple use	0	0	0	2	588	1,453	2	588	1,453
B	Total Historical, Ethnological and Archaeological Areas	49	6,317	15,609	204	6,286	15,532	253	12,603	31,141
C_1	Unique natural area or monument, fully protected	2	1,504	3,716	65	207,242	512,089	67	208,746	515,805
C_2	Unique natural area or monument, primarily for outdoor recreation, some exploitation	0	0	0	42	1,568,643	3,876,064	42	1,568,643	3,876,064
C_3	Unique natural area or monument, multiple use	0	0	0	1	18,908	46,720	1	18,908	46,720
C	Total Unique Natural Areas or Monuments	2	1,504	3,716	108	1,794,793	4,434,873	110	1,796,297	4,438,589

	Class of Park	Natural and Historic Parks			Provincial Parks			Total		
		No.	Area hectares	Area acres	No.	Area hectares	Area acres	No.	Area hectares	Area acres
D_1	Natural environment recreation area, large, fully protected	4	58,406	144,320	88	670,498	1,656,779	92	728,904	1,801,099
D_2	Natural environment recreation area, large, primarily for outdoor recreation, some exploitation	0	0	0	65	1,815,210	4,485,322	65	1,815,210	4,485,322
D_3	Natural environment recreation area, large, multiple use	0	0	0	5	480,122	1,186,364	5	480,122	1,186,364
D	Total natural environment recreational areas, large	4	58,406	144,320	158	2,965,830	7,328,465	162	3,024,236	7,472,785
E_1	Specialized recreation area, intensively developed, fully protected	0	0	0	298	18,858	46,597	298	18,858	46,597
E_2	Specialized recreation area, intensively developed, primarily for outdoor recreation, some exploitation	0	0	0	164	12,492	30,868	164	12,492	30,868
E_3	Specialized recreation area, intensively developed, multiple use	0	0	0	0	0	0	0		0
E	Total specialized recreational areas, intensively developed	0	0	0	462	31,350	77,465	462	31,350	77,465

	Class of Park	Natural and Historic Parks			Provincial Parks			Total		
		No.	Area		No.	Area		No.	Area	
			hectares	acres		hectares	acres		hectares	acres
F_1	Parkways and Highway Parks, fully protected	0	0	0	450	3,421	8,452	450	3,421	8,452
F_2	Parkways and Highway Parks, primarily for outdoor recreation, some exploitation	0	0	0	206	888	2,195	206	888	2,195
F_3	Parkways and Highway Parks, multiple use	0	0	0	1	73	181	1	73	181
F	Total Parkways and Highway Parks	0	0	0	657	4,382	10,828	657	4,382	10,828
	Total all parks classes A_1 to F_3	69	7,662,616	18,934,065	1632	24,278,272	59,990,789	1701	31,940,888	78,924,854
G	Park and Recreational Reserves (Land Bank)	0	0	0	182	551,528	1,362,807	182	551,528	1,362,807
	Grand total (A - G) All Parks + Land Bank	69*	7,662,616	18,934,065	1814	24,829,800	61,353,596	1883	32,492,416	80,287,661

* one more National Park on the Pacific Coast has been added since this table was compiled

APPENDIX III

ORGANIZATIONS CONCERNED WITH CONSERVATION IN CANADA

The following list gives the names and addresses of international, federal, provincial and private organizations (including societies) concerned with the conservation of natural resources in Canada.

It is not claimed that the list is complete. In many cases just the title of a parent body is given and the many affiliated or component societies or departments are not listed. The Canadian universities have not been included as nearly all of them are involved in conservation research or education in one form or another. The universities make a major contribution to conservation and many faculty members are involved in international organizations concerned with the maintenance of natural resources. The addresses given were the most recent available at the time of writing.

ORGANIZATIONS CONCERNED WITH CONSERVATION IN CANADA

INTERNATIONAL

1. CANADIAN COMMITTEE INTERNATIONAL BIOLOGICAL PROGRAM
(CCIBP)
P.O. BOX 110,
STE. ANNE DE BELLEVUE, P.Q.

2. CANADIAN NATIONAL COUNCIL OF INTERNATIONAL HYDROLOGICAL DECADE
(CNCIHD)
c/o DEPARTMENT OF FISHERIES & FORESTRY
NO. 8 BUILDING,
CARLING AVENUE,
OTTAWA, K1AOH3, ONT.

3. CANADIAN SCIENTIFIC COMMITTEE FOR GLOBAL ATMOSPHERIC RESEARCH PROGRAMME
(CSC for GARP)
c/o CANADIAN MICROMETEOROLOGICAL RESEARCH UNIT
DEPARTMENT OF TRANSPORT,
315 BLOOR STREET WEST,
TORONTO, 181, ONT.

4. COMMONWEALTH FORESTRY COMMISSION (CFC)
25 SAVILE ROW,
LONDON, W1X2AY, BRITAIN

5. FOOD & AGRICULTURE ORGANIZATION
(FAO)
VIALE DELLA TERME DI CARACALLA,
ROME, ITALY.

6. INTERNATIONAL FIELD YEAR FOR THE GREAT LAKES
(IFYGL)
c/o DEPARTMENT OF FISHERIES & FORESTRY,
P.O. BOX 5050,
867 LAKESHORE BOULEVARD,
BURLINGTON, ONT.

7. INTERNATIONAL UNION FOR CONSERVATION OF NATURE AND NATURAL RESOURCES
(IUCN)
MORGES, SWITZERLAND.

8. INTERNATIONAL UNION OF FORESTRY RESEARCH ORGANIZATIONS
(IUFRO)
c/o DEPARTMENT OF FISHERIES & FORESTRY
WEST MEMORIAL BUILDING,
OTTAWA 4, ONT.

9. ORGANIZATION FOR ECONOMIC CO-OPERATION & DEVELOPMENT (OECD)
   2 RUE ANDRE-PASCAL
   PARIS 16e, FRANCE

10. SPECIAL COMMITTEE ON PROBLEMS OF THE ENVIRONMENT (SCOPE)
    c/o CANADIAN MICROMETEOROLOGICAL RESEARCH UNIT,
    DEPARTMENT OF TRANSPORT,
    315 BLOOR STREET WEST,
    TORONTO 181, ONT.

FEDERAL GOVERNMENT

11. CANADA DEPARTMENT OF AGRICULTURE
    SIR JOHN CARLING BUILDING,
    CARLING AVENUE,
    OTTAWA, ONT.

12. DEPARTMENT OF ENERGY, MINES & RESOURCES
    588 BOUTH STREET,
    OTTAWA, ONT.

13. DEPARTMENT OF FISHERIES & FORESTRY
    SIR CHARLES TUPPER BUILDING,
    RIVERSIDE DRIVE,
    OTTAWA, ONT.

14. DEPARTMENT OF INDIAN AFFAIRS & NORTHERN DEVELOPMENT
    CENTENNIAL TOWER,
    400 LAURIER AVENUE, WEST,
    OTTAWA, ONT.

15. DEPARTMENT OF REGIONAL ECONOMIC EXPANSION,
    SIR GUY CARLETON BUILDING,
    161 LAURIER AVENUE WEST,
    OTTAWA, ONT.

16. NATIONAL CAPITAL COMMISSION
    41 RIDEAU STREET,
    OTTAWA, ONT.

17. NATIONAL MUSEUMS OF CANADA
    CENTURY BUILDING,
    360 LISGAR STREET,
    OTTAWA, ONT.

PROVINCIAL GOVERNMENT

BRISISH COLUMBIA

18. BRITISH COLUMBIA FOREST SERVICE
PARLIAMENT BUILDINGS,
VICTORIA, B.C.

19. DEPARTMENT OF LANDS, FORESTS, AND WATER RESOURCES
VICTORIA,
B.C.

20. DEPARTMENT OF RECREATION & CONSERVATION
VICTORIA,
B.C.

ALBERTA

21. DEPARTMENT OF LANDS & FORESTS
10526 JASPER AVENUE,
EDMONTON, ALTA.

SASKATCHEWAN

22. FORESTRY BRANCH
DEPARTMENT OF NATURAL RESOURCES
GOVERNMENT ADMINISTRATION BUILDING,
REGINA, SASK.

MANITOBA

23. DEPARTMENT OF MINES & NATURAL RESOURCES
BUILDING 14,
FORT OSBORNE COMPLEX,
BOX 18,
139 TUXEDO BOULEVARD,
WINNIPEG 29, MAN.

24. PARKS BRANCH
DEPARTMENT OF TOURISM & RECREATION,
WINNIPEG, MAN.

ONTARIO

25. DEPARTMENT OF ENERGY & RESOURCES MANAGEMENT
PARLIAMENT BUILDINGS,
TORONTO, ONT.

26. DEPARTMENT OF LANDS & FORESTS
PARLIAMENT BUILDINGS,
QUEENS PARK,
TORONTO, ONT.

27. THE NIAGARA PARKS COMMISSION
BOX 150,
NIAGARA FALLS, ONT.

QUEBEC

28. DEPARTMENT OF LANDS & FORESTS
PARLIAMENT BUILDINGS,
QUEBEC CITY, P.Q.

29. DEPARTMENT OF NATURAL RESOURCES
QUEBEC,
P.Q.

30. DEPARTMENT OF TOURISM, FISH & GAME
QUEBEC,
P.Q.

NEW BRUNSWICK

31. DEPARTMENT OF FISHERIES
LEGISLATIVE BUILDINGS,
FREDERICTON, N.B.

32. DEPARTMENT OF LANDS & MINES
FREDERICTON,
N.B.

33. DEPARTMENT OF NATURAL RESOURCES
CENTENNIAL BUILDINGS,
FREDERICTON, N.B.

NOVA SCOTIA

34. DEPARTMENT OF FISHERIES
HALIFAX,
N.S.

35. DEPARTMENT OF LANDS & FORESTS
PROVINCIAL BUILDING,
HALIFAX, N.S.

PRINCE EDWARD ISLAND

36. DEPARTMENT OF INDUSTRY, NATURAL RESOURCES & FISHERIES
CHARLOTTETOWN,
P.E.I.

NEWFOUNDLAND

37. DEPARTMENT OF FISHERIES
CONFEDERATION BUILDING,
ST. JOHNS, NEWF.

38. DEPARTMENT OF MINES, AGRICULTURE & RESOURCES
ST. JOHNS,
NEWF.

39. NEWFOUNDLAND FORESTRY SERVICE
CONFEDERATION BUILDINGS,
ST. JOHNS, NEWF.

SOCIETIES & PRIVATE ORGANIZATIONS

NATIONAL ORGANIZATIONS

40. ATLANTIC SALMON ASSOCIATION
1255 UNIVERSITY STREET,
MONTREAL 100, P.Q.

41. ARCTIC INSTITUTE OF NORTH AMERICA
3458 REDPATH STREET,
MONTREAL 25, QUE.

42. CANADIAN AUDUBON SOCIETY
46 ST. CLAIR AVENUE EAST,
TORONTO 7, ONT.

43. CANADIAN COUNCIL ON 4-H CLUB
185 SOMERSET STREET WEST,
OTTAWA, ONT.

44. CANADIAN FORESTRY ASSOCIATION
SUITE 303,
185 SOMERSET STREET WEST,
OTTAWA, ONT.

45. CANADIAN HISTORICAL ASSOCIATION
UNIVERSITY OF TORONTO,
TORONTO, ONT. (35 Affiliated Societies)

46. CANADIAN INSTITUTE OF FORESTRY
BOX 5000,
MACDONALD COLLEGE, P.Q.

47. CANADIAN MUSEUMS ASSOCIATION
MANITOBA MUSEUM OF MAN & NATURE,
WINNIPEG, MAN.

48. CANADIAN PARKS RECREATION ASSOCIATION
214 MERTON STREET,
SUITE 104,
TORONTO 295, ONT.

49. CANADIAN PULP & PAPER ASSOCIATION
2280 SUN LIFE BUILDING,
MONTREAL, P.Q.

50. CANADIAN SOCIETY OF LANDSCAPE ARCHITECTS
BOX 3304,
POSTAL STATION C
OTTAWA, ONT.

51. CANADIAN TOURIST ASSOCIATION
8 KING STREET EAST,
TORONTO 210, ONT.

52. CANADIAN WATER RESOURCES ASSOCIATION
BOX 340,
REDCLIFFE, ALTA.

53. CANADIAN WILDLIFE FEDERATION
37 QUEENSLINE DRIVE,
OTTAWA 6, ONT.

54. NATIONAL & PROVINCIAL PARKS ASSOCIATION
SUITE 18,
43 VICTORIA ST.,
TORONTO 1, ONT.

55. THE ALPINE CLUB OF CANADA
P.O. BOX 1026,
BANFF, ALTA.

56. THE CANADIAN BOTANICAL ASSOCIATION
c/o DEPARTMENT OF BOTANY,
UNIVERSITY OF BRITISH COLUMBIA,
VANCOUVER, B.C.

57. THE CANADIAN INSTITUTE ON POLLUTION CONTROL
P.O. BOX 66,
DON MILLS, ONT.

58. THE NATURE CONSERVANCY OF CANADA
1407 YONGE STREET,
TORONTO 7, ONT.

59. WOODLANDS SECTION
CANADIAN PULP & PAPER ASSOCIATION,
2300 SUN LIFE BUILDING,
MONTREAL, P.Q.

BRITISH COLUMBIA

60. ASSOCIATION OF BRITISH COLUMBIA PROFESSIONAL FORESTERS
4580 WEST TENTH AVENUE,
VANCOUVER 8, B.C.

61. BRITISH COLUMBIA NATURE COUNCIL
2250 YORK STREET,
VANCOUVER, B.C.

62. BRITISH COLUMBIA WATERFOWL SOCIETY
BOX 2582,
VANCOUVER, B.C.

63. BRITISH COLUMBIA WILDLIFE FEDERATION
3020 SUMNER AVENUE,
BURNABY 2, B.C.

64. CANADIAN FORESTRY ASSOCIATION OF BRITISH COLUMBIA
1201 MELVILLE STREET,
VANCOUVER 5, B.C.

ALBERTA

65. ALBERTA FISH & GAME ASSOCIATION
ROOM 212,
8631 109th STREET,
EDMONTON, ALTA.

66. WESTERN CANADA CONSERVATION & RECLAMATION ASSOCIATION
BOX 340,
REDCLIFFE, ALTA.

SASKATCHEWAN

67. SASKATCHEWAN FISH & GAME LEAGUE
1122 TEMPERANCE STREET,
SASKATOON, SASK.

68. SASKATCHEWAN NATURAL HISTORY SOCIETY
REGINA CAMPUS,
UNIVERSITY OF SASKATCHEWAN,
REGINA, SASK.

69. SASKATCHEWAN RIVER DEVELOPMENT ASSOCIATION
604 MAIN NORTH,
MOOSE JAW, SASK.

MANITOBA

70. DUCKS UNLIMITED (CANADA)
389 MAIN STREET,
WINNIPEG, MAN.

71. MANITOBA ARCHAEOLOGICAL SOCIETY
P.O. BOX 1171,
WINNIPEG 1, MAN.

72. MANITOBA WILDLIFE FEDERATION
1770 NOTRE DAME AVENUE,
WINNIPEG, MAN.

73. PRAIRIE PROVINCES FORESTRY ASSOCIATION
4809 CORYDON AVENUE,
WINNIPEG 9, MAN.

ONTARIO

74. AIR POLLUTION CONTROL ASSOCIATION
67 COLLEGE STREET,
TORONTO 2, ONT.

75. ASSOCIATION OF TOURIST RESORTS OF ONTARIO
68 YONGE STREET,
SUITE 808,
TORONTO, ONT.

76. CONSERVATION COUNCIL OF ONTARIO
SUITE 604,
11 ADELAIDE STREET WEST,
TORONTO, ONT.

77. FEDERATION OF ONTARIO NATURALISTS
1262 DON MILLS ROAD,
DON MILLS, ONT.

78. ONTARIO ARCHAEOLOGICAL SOCIETY
207 TRUMAN RD.,
WILLOWDALE, ONT.

79. ONTARIO FEDERATION OF ANGLERS & HUNTERS
BOX 309,
WILLOWDALE, ONT.

80. ONTARIO FORESTRY ASSOCIATION
229 COLLEGE STREET,
TORONTO 2B, ONT.

81. ONTARIO HISTORICAL SOCIETY
40 EGLINTON AVENUE EAST,
TORONTO, ONT. (57 Affiliated Societies)

82. ONTARIO PROFESSIONAL FORESTORS ASSOCIATION
31 YONGE STREET NORTH,
SUITE 34,
RICHMOND HILL, ONT.

83. ONTARIO SHADE TREE COUNCIL
1643 YONGE STREET,
TORONTO 7, ONT.

84. ONTARIO WATERFOWL RESEARCH FOUNDATION
BOX 163,
GUELPH, ONT.

85. THE ALGONQUIN WILDLANDS LEAGUE
BOX 114,
POSTAL STATION Q,
TORONTO 7, ONT.

86. THE OTTAWA FIELD-NATURALISTS CLUB
BOX 3264,
POSTAL STATION C,
OTTAWA 3, ONT. (8 Affiliated Societies)

QUEBEC

87. CERCLE DES JEUNES NATURALISTES
JARDIN BOTANIQUE, CH 124,
4101 EST SHERBROOKE,
MONTREAL 36, P.Q.

88. CORPORATION OF FOREST ENGINEERS OF THE PROVINCE OF QUEBEC
BOX 57,
QUEBEC 6, P.Q.

89. LA JEUNE SCIENTIFIQUE
CASE POSTALE 391,
JOLIETTE, P.Q.

90. OTTAWA FOREST PROTECTIVE ASSOCIATION
P.O. BOX 37,
PEMBROKE, ONT.

91. PROVINCE OF QUEBEC SOCIETY FOR PROTECTION OF BIRDS
164 SENNERVILLE ROAD,
SENNEVILLE, P.Q.

92. QUEBEC WILDLIFE CONSERVATION ASSOCIATION
1559 MCGREGOR STREET,
MONTREAL 25, P.Q.

93. QUEBEC WILDLIFE FEDERATION
1600 BERRI STREET,
SUITE 210,
MONTREAL 24, P.Q.

94. THE PROVANCHER SOCIETY OF NATURAL HISTORY IN CANADA
1160 BOURLAMAQUE STREET,
QUEBEC CITY, P.Q.

NEW BRUNSWICK

95. ASSOCIATION OF REGISTERED PROFESSIONAL FORESTORS OF NEW BRUNSWICK
BOX 23,
FREDERICTON, N.B.

96. CANADIAN FORESTRY ASSOCIATION OF NEW BRUNSWICK INC.
BOX 158,
MARITIME FOREST RANGER SCHOOL,
FREDERICTON, N.B.

97. NEW BRUNSWICK WILDLIFE FEDERATION
P.O. BOX 872,
ST. JOHN, N.B.

NOVA SCOTIA

98. NOVA SCOTIA FISH & GAME ASSOCIATION
P.O. BOX 654,
HALIFAX, N.S.

PRINCE EDWARD ISLAND

99. PRINCE EDWARD ISLAND FISH & GAME ASSOCIATION
22 WEST STREET,
CHARLOTTETOWN, P.E.I.

NEWFOUNDLAND

100. NEWFOUNDLAND-LABRADOR WILDLIFE FEDERATION
42 WEST VALLEY ROAD,
CORNER BROOKE, NEWF.

NORTHWEST & YUKON TERRIRORIES

101. THE NORTHWEST TERRITORIES ANGLERS & HUNTERS ASSOCIATION
YELLOWKNIFE,
NORTHWEST TERRITORIES

102. WESTERN CANADA-YUKON FISH & GAME COUNCIL
BOX 376,
GANGES - SALT SPRING ISLAND, B.C.

103. YUKON FISH & GAME ASSOCIATION
BOX 2573,
WHITEHORSE, YUKON TERRITORY.